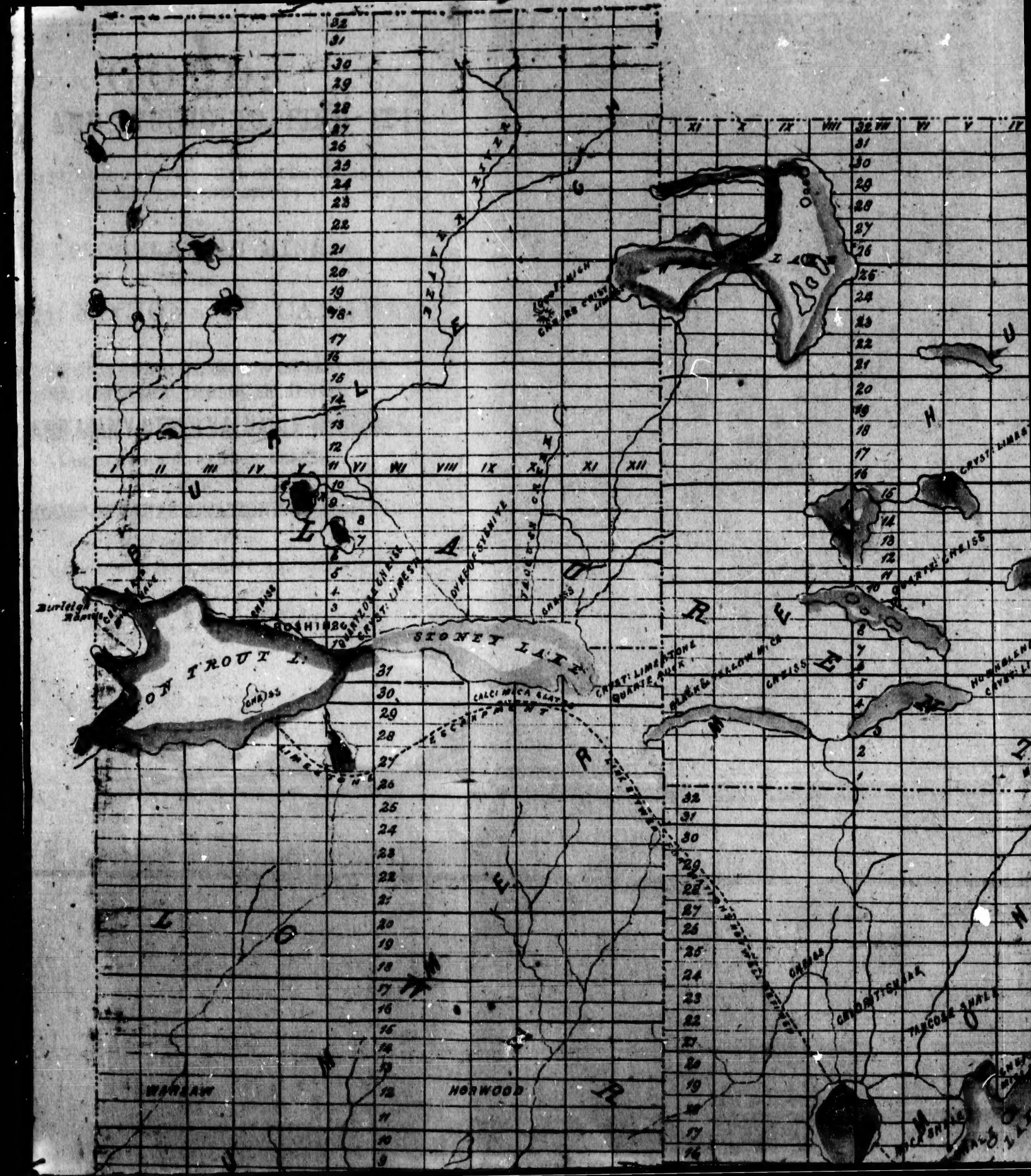
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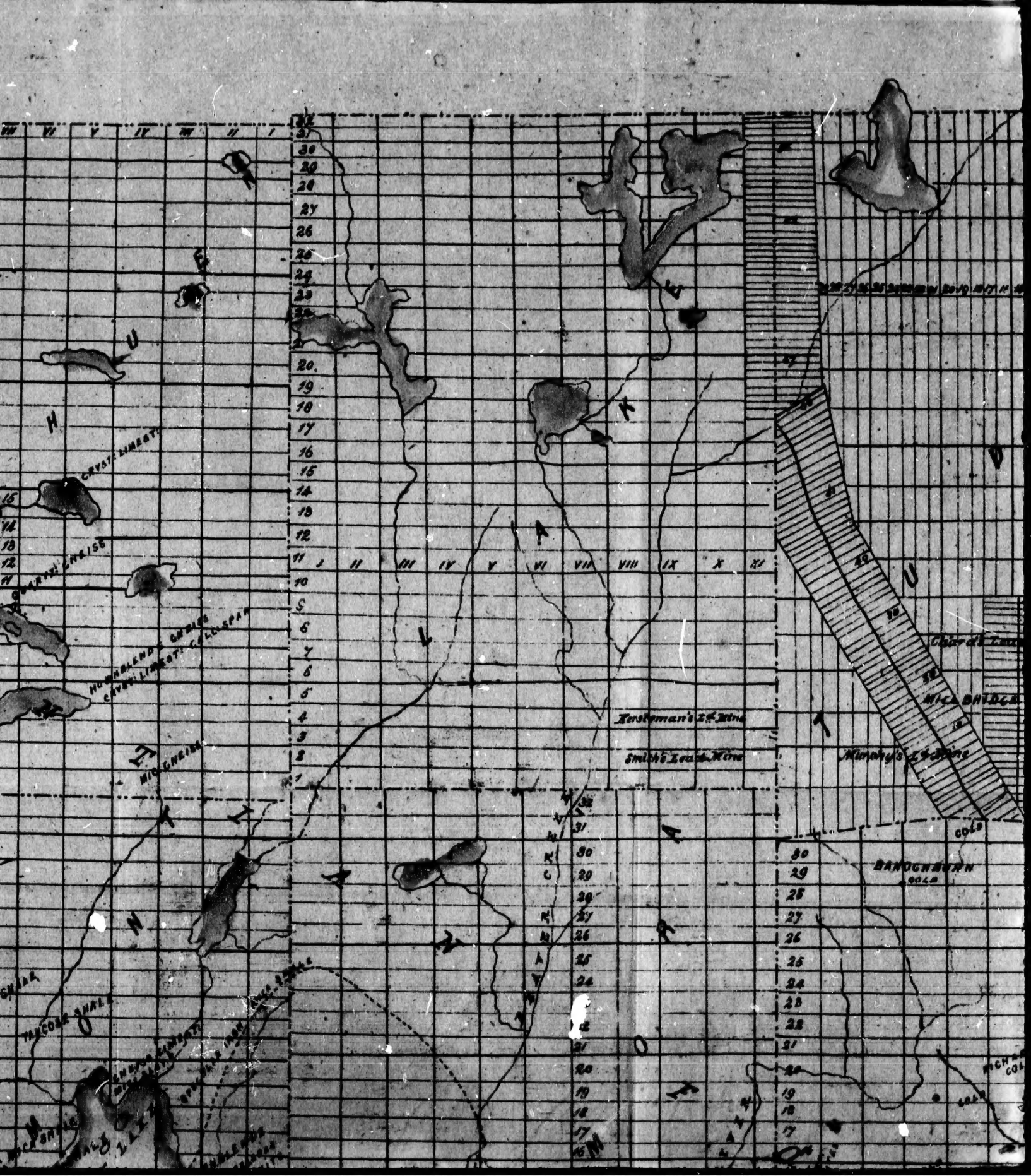
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Murphy's Leads
MICA BRIDGE
BANOGHBUNN
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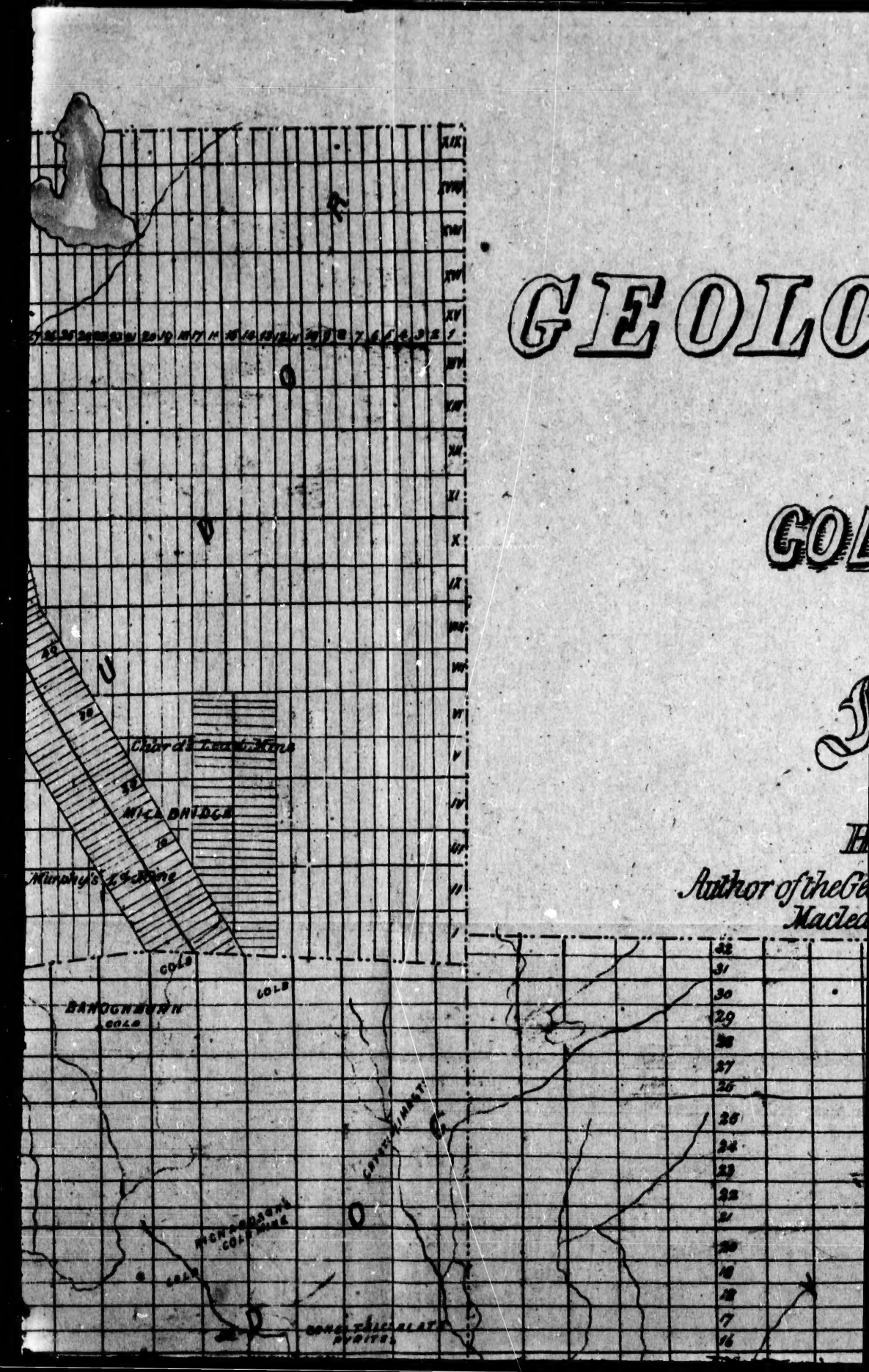
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OLOGICAL MAP

OF THE

GOLD REGIONS

OF

MADOC

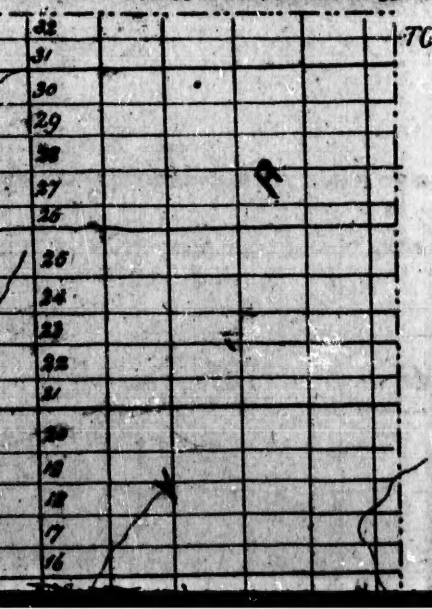
BY

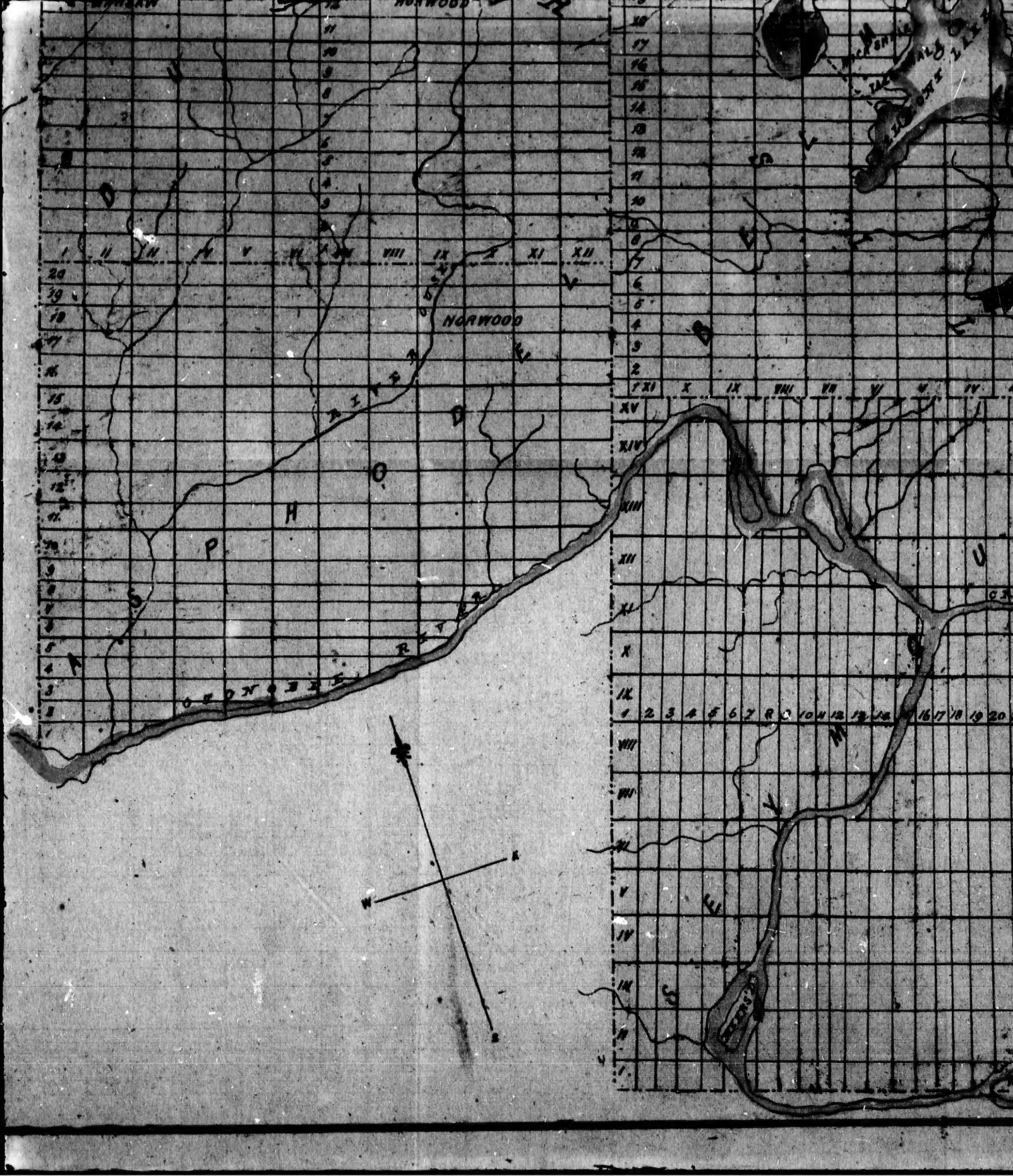
HENRY WHITE P.L.S:

Author of the Geology, Oil-fields and Minerals of Canada West

Maclear and Co. Publishers: 17 King St. West

TORONTO

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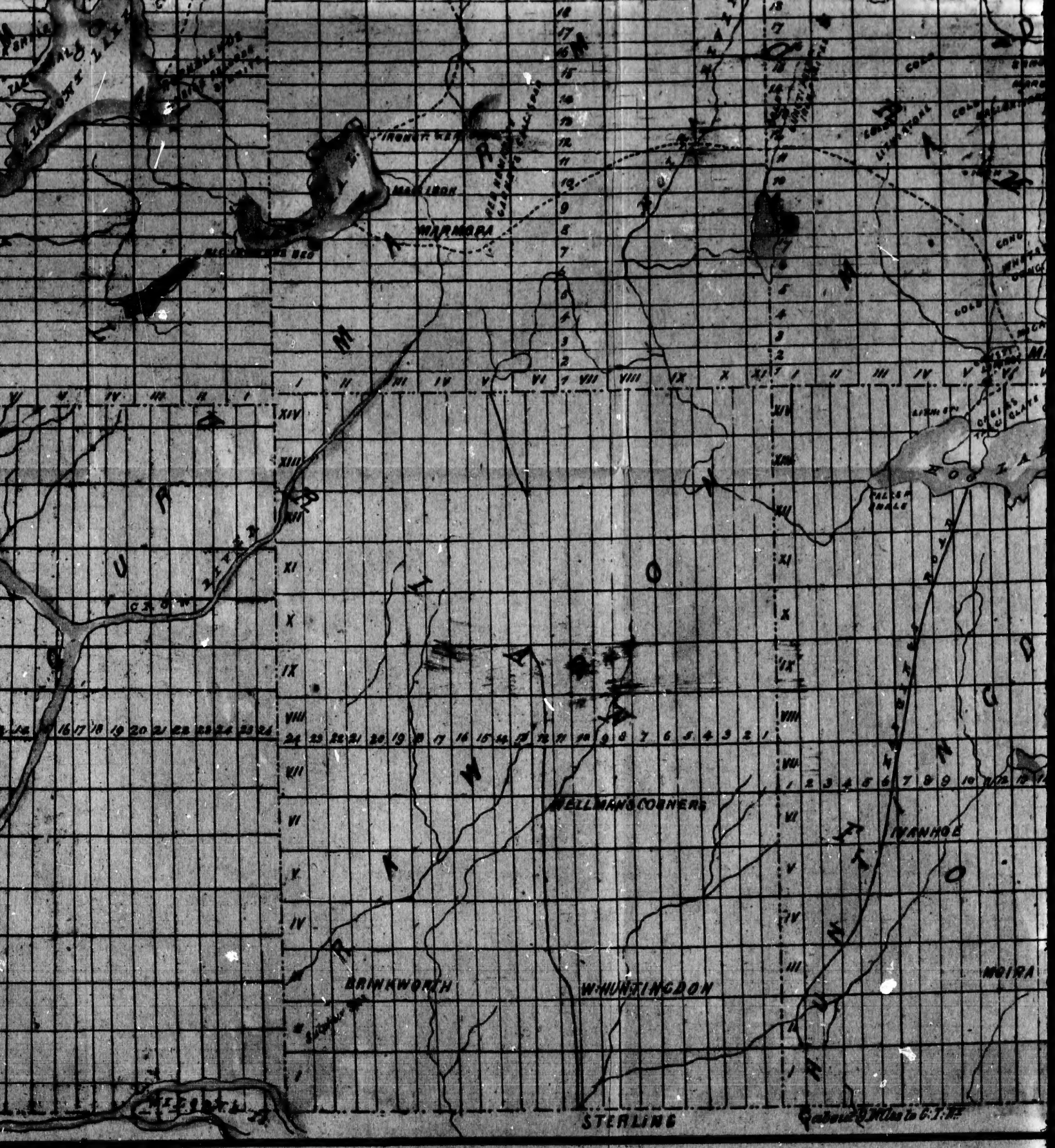
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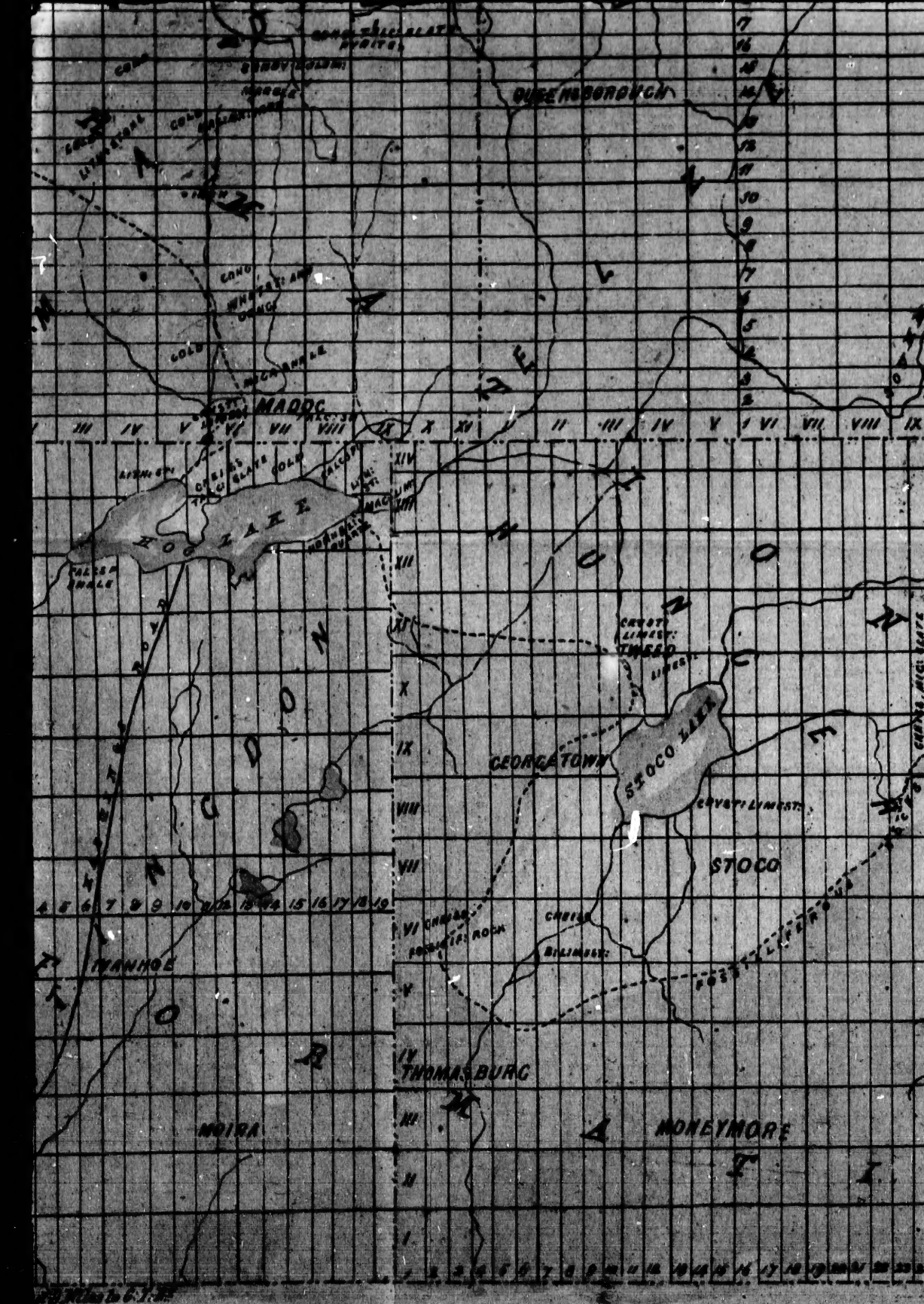
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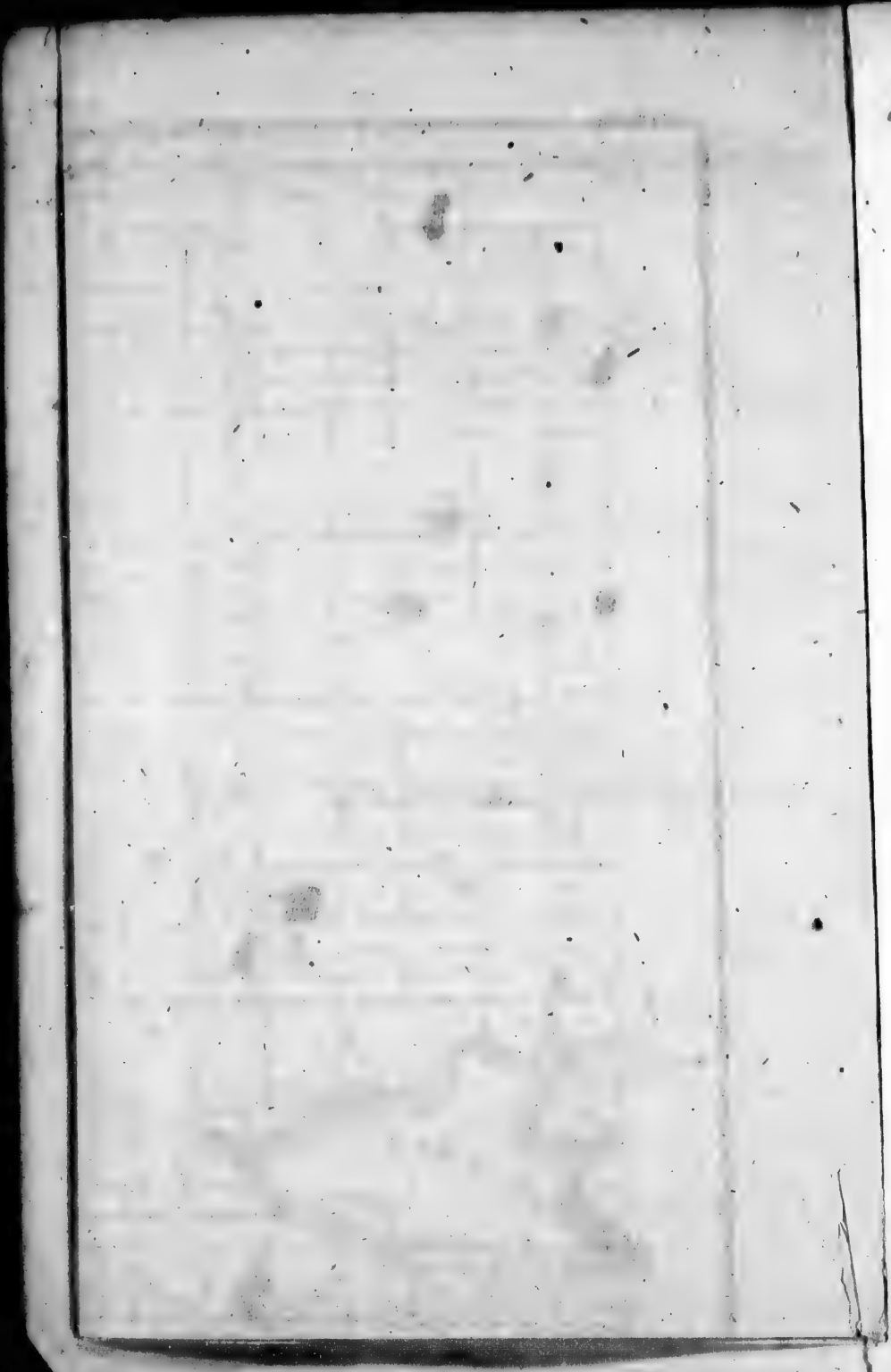

GOLD REGIONS OF CANADA.

GOLD:

HOW AND WHERE TO FIND IT!

THE

EXPLORER'S GUIDE AND MANUAL OF PRACTICAL AND INSTRUCTIVE DIRECTIONS

FOR

EXPLORERS AND MINERS

IN THE

GOLD REGIONS OF CANADA,

WITH

LUCID INSTRUCTIONS AND EXPLANATIONS AS TO THE ROCKY STRATA, PECULIAR SHALE ROCKS, VEINSTONE, ETC., IN WHICH

GOLD, AND MANY OTHER VALUABLE MINERALS,

ARE TO BE FOUND IN THAT REGION;

WITH

EASY MODES OF DETERMINATION AND ANALYSIS,

ACCOMPANIED BY TWO

COLORED GEOLOGICAL MAPS.

BY HENRY WHITE, P.L.S.,
Author of the "Geology, Oil Fields, and Minerals of Canada West," etc., etc., etc.

TORONTO:
PUBLISHED BY MACLEAR & CO.,
17 KING STREET WEST.,
1867.

LP TN424.C2W5

PREFACE.

The object of the following pages is, to supply the gold mining emigrant coming into Canada, as well as those already in this country, with the information necessary to enable them to conduct, with facility and certainty, the researches and operations which are essentially necessary to a successful issue in gold mining, as well as that of other operations of a similar nature. There can be no doubt but Canada affords greater accommodation, in consequence of its commercial facilities, for the successful prosecution of gold mining, than any other large gold producing country in the world, and there is less doubt, that a larger share of its mineral riches will ultimately fall to the lot of the intelligent and industrious mining student. The man who comes into this country, and makes himself acquainted (by the study of the following, or any other comprehensive intelligible work) with the conditions under which gold, or any other valuable metallic ore occurs, and is to be found, and the operations by which they may be most readily extracted from their native beds, will evidently find himself in advance and more successful than the less intelligent adventurer who trusts in chance alone for success.

This work is therefore expressly prepared, with its accompanying geological maps, as a manual for explorers, and is designed to supply a want now very generally felt, respecting the Madoc Gold discoveries, and the occurrence of other valuable minerals in that (comparatively)

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unexplored and extensive region of Laurentian rocks.

The work opens with a short description of the nature and character of the older rock composing the earth. Then follow in succession a further short description of the more recent rocky strata, their character, and distinguishing features, and metallic bearing veins, and shales, in the gold-bearing formation of this country, so that the explorer may readily distinguish the one from the other when he sees them, and search *only* in those places, stratas, and veinstones, which are pointed out in the body of the work, for his guidance, instead of making an indiscriminate and hopeless random search in all rocky stratas he may meet with.

There is also given such a description of the appearance, nature and characteristics of the Laurentian or gold-bearing rocks, as will enable the explorer at once to distinguiah them from the rocks of the Silurian formation lying on its south side. Besides which he is also refered to the accompanying geological maps, on which he will see the line of contact between the two formations, distinctly marked, so that he need not in any case mistake his geological or geographical position in relation to the gold-bearing formation.

A description of all the most valuable minerals that are known to exist in, and belonging to that formation, is also given in detail, with easy modes of determination and analysis, and much valuable information, respecting the proper places and veinstones in which to search for gold, &c., &c., with plain and practical methods of ascertaining its existence in Talcoso or chloritic shale, quartz rock, iron pyrites, alluvial deposits, red ochre, or black sand.

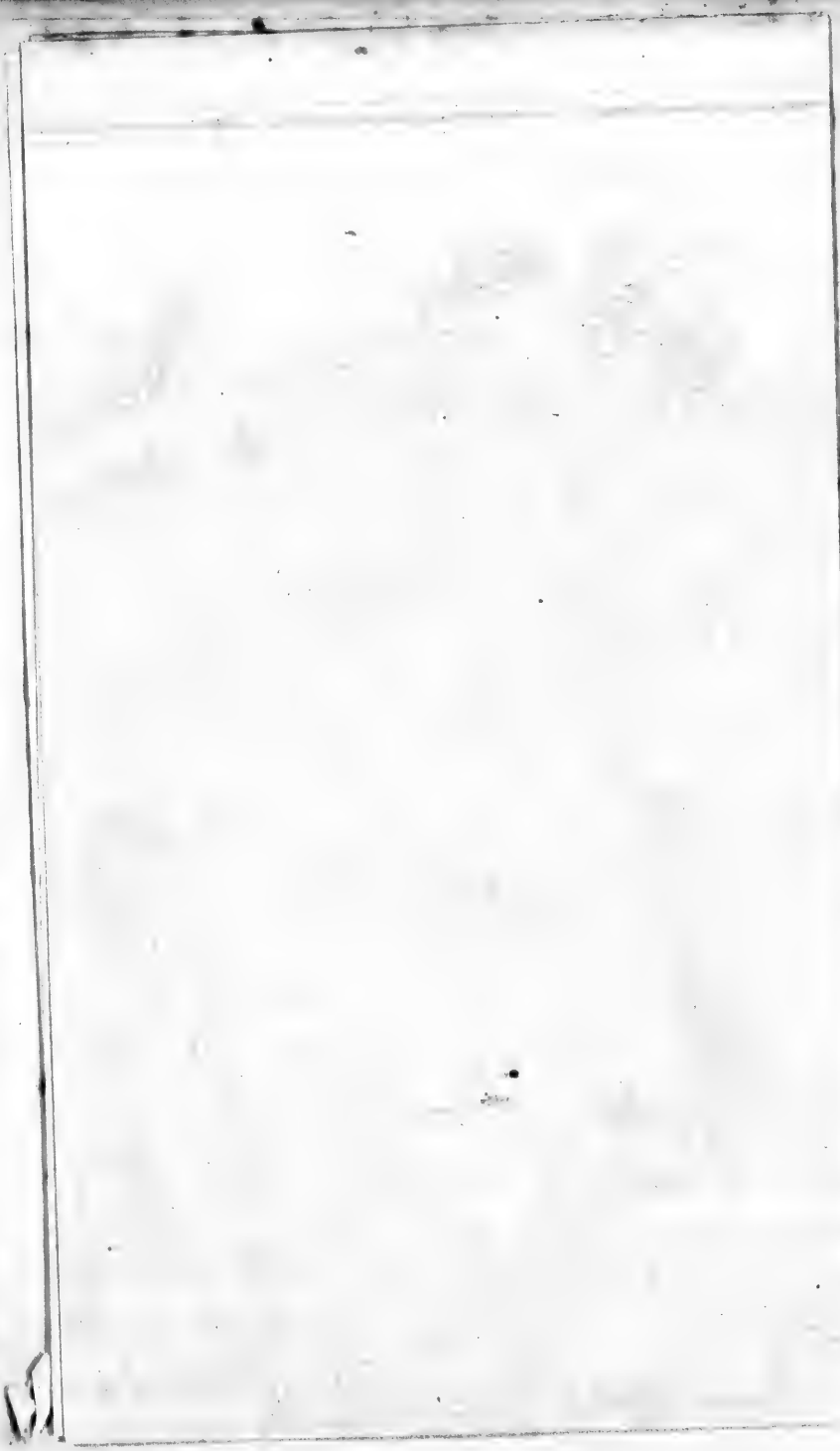
The author has endeavoured to keep as clear as possible from technical terms and incomprehensible phraseology, thereby rendering the work as plain, practical and intelligible as possible, so that it may be easily understood by every person who may read it.

The want of a plain, cheap, and comprehensive work of this kind is severely felt in Canada just now, and the great tide of explorers and gold seeking emigrants that will, on the opening of navigation, visit the Gold Regions of Western Canada, will make it doubly so.

The few works we have in Canada are either too elaborate, too scientific, and too expensive, or are the production of foreign countries, and adapted only to their geological conditions and mineral characters, and wholly inadequate to the wants of the Canadian explorer.

To supply this want in the requirements of our young, but great and undeveloped mineral country, and to place in the hands of the venturous explorer, such information and guidance as he must necessarily require to be successful, and, without which his labour will be in vain, is the object of this book, and the author reasonably believing that his long professional practise as a P.L.S. and mineral explorer, through the rocky wilds of Canada, render him not unfit for the compilation and accomplishment of the following exposition of the undeveloped mineral resources of the Laurentian formation of Canada, of which the following pages principally treat.

Toronto, April, 1867.



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LINDSAY
PETERBORO
PORT HOPE
COBOURG
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BELLEVILLE
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LAKE ONTARIO
N. ONTARIO

GEOLOGICAL MAP

OF THE

COLD RECIONS

OF

CANADA WEST

BY

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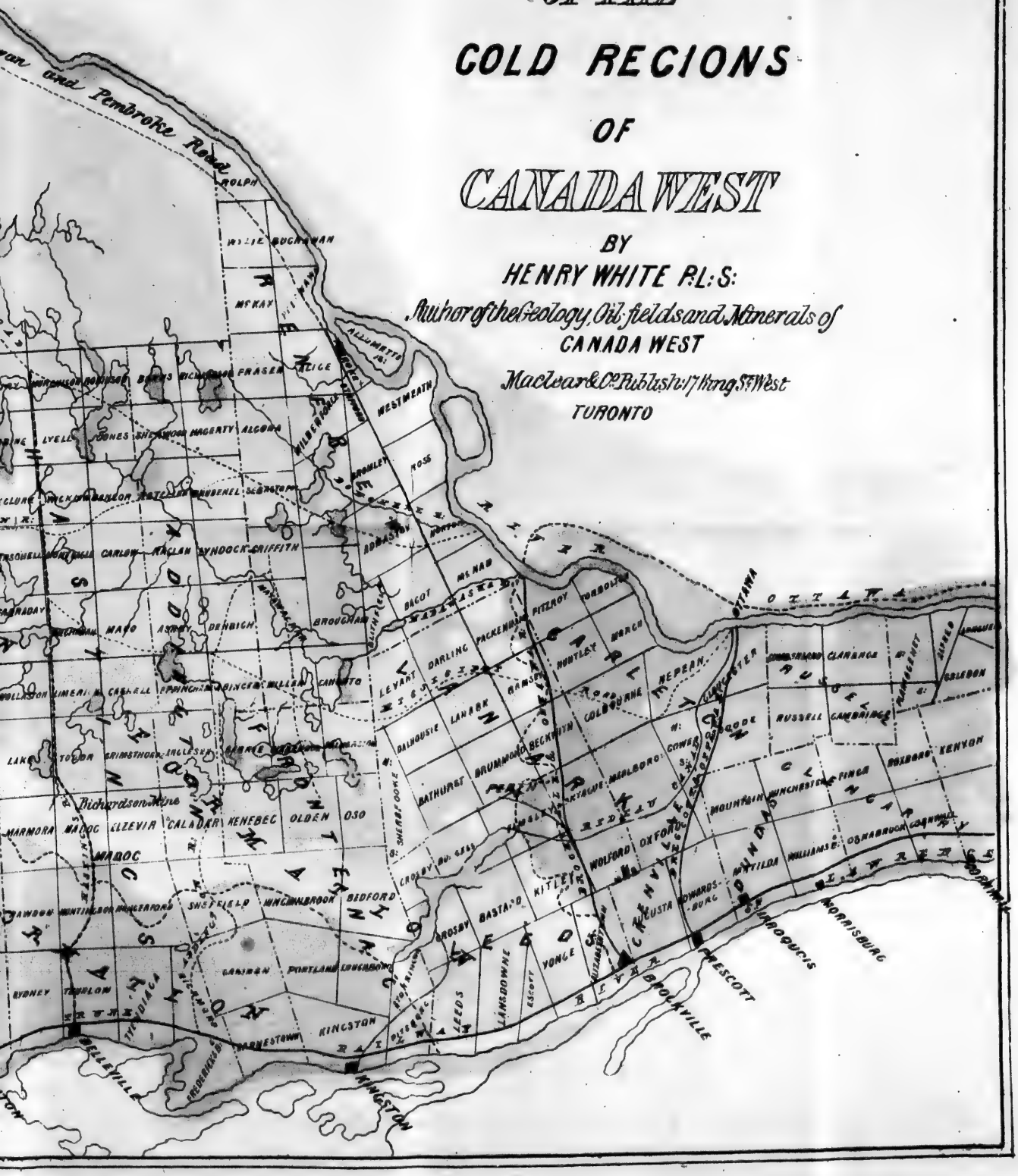


GOLD REGIONS OF CANADA.

STRUCTURE OF ROCKS.

The rocks of the globe consist either of a single mineral in a massive state or of intimate combinations of different minerals. For instance, limestone, when pure, is a single mineral—it is the species calcite or carbonate of lime: Common *Granite* is a compound aggregate of *three* minerals, quartz, feldspar and mica. It is an *unstratified rock*. Sandstones may consist of grains of quartz alone, like the sands of the sea shore which, if compressed or agglutinated together, will form compact sand rock. It is common to find along with the quartz sand, grains of feldspar and sometimes mica. When this aggregate is compressed or agglutinated together, they produce *gneiss*, which is a *stratified* rock. Clay slates consist of quartz and feldspar or clay, with sometimes mica, all so finely comminuted, that often the grains cannot be observed. *Conglomerates* are aggregates of pebbles of any kind. They may be a mixture of granite pebbles, quartz pebbles, limestone pebbles, or mixtures of different kinds cemented together in a matrix of some cementing material, such as silica, oxyd of iron, or carbonate of lime.

Rocks differ also in texture. In some, as granite, or syenite, the texture is crystalline: that is, the grains are more or less angular, and shew faces of cleavage; the aggregation was the result of a cotemporaneous crystalization of the several component parts. White marble, crystalline limestone, &c., consists of angular grains, and are crystalline. But a conglomerate is not a result of crystallization; it consists only of adhering small pebbles in a matrix of cementing material, which is sometimes not apparent. Sandstones, in like manner, are also an agglutination of grains of sand, and can be formed by compressing sand under a heavy pressure. Clay or roofing slates are nothing more than what would result from the compressing and solidifying a bed of clay, containing silica, alumina, and a little iron. There are, therefore, *stratified* and *unstratified*, crystalline and uncrystalline rocks. But it must be borne in mind, that, in each kind of rock, the grains themselves are crystalline, as all solid matter becomes solid by crystallization. But the former is a crystallized aggregation of grains, while the latter is only mechanical. In crystalline rocks it is not always possible to distinguish the grains, as they may be so minute, or

the rock so compact, that they are not visible. Much of the crystalline rock called basalt is thus compact.

Much of the rocky structure of the earth's surface constitute extensive beds or layers, lying one above the other, and varying in thickness, from the fraction of an inch, to many feet. There are compact limestones, beds of sandstones, and shales or clay slates, in many and various alterations. In some regions certain of these rocks, or certain parts of the series, may extend over certain large areas, or underlie a whole country, while others are wholly wanting, or present only in their beds. The irregularities in their original deposition, their geographical arrangement, and in the order of superposition, are very numerous, and it is one object of geology to discover order and harmony amid such apparent want of system. Many of these rocks contain its own peculiar organic remains, and this is one source of the confident decision of the geologist as to the relation, age and position in which they ought to be placed, in the scale of the earth's structure. The stratified rocks bear evidence in every part—in their regular layers, their worn sand or pebbles, and their fossils—that they are the result of gradual accumulations of sedentary matter beneath the ancient oceans, marine or fresh, or on the shores of seas, lakes, or rivers. Besides these stratified rocks, there are others, which, like the ejections from a volcano, or an igneous vent, form beds or break through other strata, and fill fissures, often many miles in length. The rock filling such fissures is called a dyke. Porphyry, and many of the veins in rocks, are of the same kind, and have the same origin. Similar rocks sometimes occur as extensive layers; for the lavas of a single volcanic eruption have been known to be continuous for over forty miles, and may appear underlying a wide region of country, like granite. The stratified rocks, or such as consist of material in regular layers, are of two kinds. The worn grains of which they are composed are sometimes distinct, and the remains of shells further indicate that they are the result of gradual accumulations. But others, or even certain parts of beds, that elsewhere contain these indications, have a crystalline texture. A limestone bed may be compact in one part, and granular or crystalline, like statuary marble, in another, evidently showing the effect of heat on one position of the bed, since the rock was deposited. There are other rocks, such as mica slate, gneiss, and probably some granites, that have thus been crystallized. They are called metamorphic rocks.

Following this brief description of the arrangement and general nature of rocks, which is deemed necessary to the proper understanding of what follows, we will proceed with a description of the more prominent varieties that occur in the formation of which we are about to treat, with a description of the probable extent and characteristic features of that formation, so that it may be readily distinguished from all others.

Granite consists of three minerals, quartz, feldspar, and mica. It has a somewhat coarse crystalline granular structure, and usually a grayish-white, gray or flesh-red color, the shade varying with the color of the prevailing mineral of which it is composed. When it contains an excess of quartz it is whiter, when an excess of feldspar, it assumes a redder color, and when mica prevails it is generally darker. When it contains hornblende in place of mica it is called *Syenite*; hornblende resembles mica in these rocks, but the laminæ is brittle, and more difficult to separate. Granite is said to be *micaceous*, *feldspatic*, or *quartzose*, according as the *mica*, *feldspar*, or *quartz* predominates It is called *porphyritic* granite when the feldspar is in large crystals, and appears over a worn surface like thickly scattered white blotches, often rectangular in shape. Graphic granite has the appearance of hieroglyphics, or oriental characters, over the surface, owing to the angular arrangement of the quartz in the feldspar or the feldspar in the quartz. When the mica of the granite is wanting it is then a granular mixture of feldspar and quartz, called granulite or leptynite. When the feldspar is replaced by *albite* it is called *albite* granite. The albite is usually white, but otherwise resembles feldspar, when replaced by *talc*, it is called protogene.

Granite is the usual rock in which tin ore is found. It contains also commercial quantities of pyritous, vitreous, and grey copper ore, galena or lead ore, zinc, blende, specular, and magnetic iron. Antimony, cobalt, nickel, uranium, arsenic, titanium, bismuth, tungsten, and silver, with rarely a trace of mercury. The rare minerals, cerium and yttria, are found in granite, and most frequently in albite granite. It also contains emerald, topaz, corundum, zircon, fluor-spar, garnet, tourmaline, pyroxene, hornblende, epidote, and many other species. But as granite is of rare occurrence among our Laurentian rocks, let explorers be cautioned that *gneiss rock is not granite*, though commonly so-called by the inexperienced. The *gneiss* rock is *stratified*, that is, full of *lines* and *seams*, while the *granite is not*. Diorite is a rock of the granite series, consisting of hornblende and feldspar. Its color is dark green or greenish black, and crystalline in texture.

Granite is a very hard and durable rock, and is one of the most valuable materials for building. It was much used by the ancients, especially the Egyptians, where are yet obelisks that have stood the weather for over 3000 years.

GNEISS OR LAURENTIAN FORMATION.

Gneiss has the same composition as granite, but is stratified in appearance. It is in fact composed of the disintegrated atoms of

the primitive granite which has been washed down and deposited in the bottom of an ancient sea, where it has become a solid stratified rock, but which has subsequently been uplifted and subjected to much violent action by heat in its early stages of consolidation, as evidenced by the disturbance and contortions of its once horizontal strata. It generally breaks into slates a few inches to a foot or more in thickness, and withers from a flesh red to an almost white color according as feldspar, mica, or quartz predominates. Where feldspar predominates it is generally of a flesh red color, and is called *feldspatic gneiss*. Where mica prevails it generally assumes a darker grey color, and is called *micaceous gneiss*. Where quartz prevails it assumes a white color, and is called *quartzose gneiss*. It is much tilted up, contorted, twisted, and overlapped, and is interspersed in many places by dykes of intrusive rock, horneblende, and other allied rocks. Extensive deposits of crystalline limestone, and large veins of quartz, feldspar, calcspar, baryta, or heavy spar, chloritic schistose, talcose shale, &c.

This formation is the oldest as well as the largest on the continent of America. It enters the Province on the Coast of Labrador, and, following along the south side of the Gulf of St. Lawrence, in an irregular line, and at irregular distances therefrom, skirts round the City of Quebec, thence up to and around the City of Ottawa, where it strikes southerly to the Thousand Islands, below Kingston; thence in nearly a straight line to the head of the Georgian Bay, near the mouth of the Severn River, and thence along the Georgian Bay, to the west side of the French River. From thence it can be traced, in broken succession, along the north shore and round the head of Lake Superior, taking in Vermillion Lake in the United States; thence to the North-East side of Lake Winnipeg; from whence it strikes towards the head waters of McKenzie River, and down the McKenzie River to the Arctic Ocean, at the extreme north end of the Rocky Mountains; a distance, from one extreme point to the other, of about 5,000 miles. The above will rudely represent the southern boundary and extreme length of this formation. But what are, or may ultimately prove to be, its northern limits, it is impossible at the present day to tell. We have however sufficient information, from personal observation and otherwise to warrant us in saying that it will range from 200 to 500 miles wide. Taking the mean of these at 350 miles, and the extreme length at 5,000, it will give an area of no less than 1,750,000 square miles, of what is now proved beyond a question of doubt to be a gold bearing rock in British America alone. This is probably greater than all the gold bearing fields in the world put together,—and this great field remains as yet a comparative incognito. It is only the southern borders of a very limited portion of it in Upper and Lower Canada, that has at all been brought under the cognizance of the Geological Survey, or private enterprise; but now, and for the future, it is destined to receive an impetus, by

private enterprise that few regions have ever known, but certainly none beyond what its great and known mineral wealth will amply justify.

This is the formation in which gold in such large quantities is now being found. It is at our very doors, borders on a fine and well settled agricultural section of country, and is itself, in many parts of its southern limits, tolerably well settled; there are roads, villages, stores, post offices, &c., &c. Rail roads and steamboats convey you to within a few hours drive of the gold fields, where the stages take you. You have not got to face the wild nation of Australia, or the savage Indian of California or British Columbia, nor have you the hardships of long inland mountainous journeys to perform, with $5 for a mess of beans or a piece of *hard tack*. All these difficulties will be obviated in the gold fields of Canada, where cheap supplies, and every convenience that a gold hunter could desire, may be obtained at the current market prices of the Province. But I am digressing.

It is very probable that it will be between Kingston and the head of the Georgian Bay, that the greater extent of explorations and works will be carried on during the incoming season. The distance across there is about 150 miles, and it is likely that *Madoc* will be the centre from whence the explorations will radiate. They will then extend to the east and west keeping on the *Gneiss rock*, along the borders of which, and for some miles to the northward, they will find plenty of farmers, and farm houses, but it is not probable that these farmers, or farm houses, will be able to afford either sufficient supplies or accommodation to the immense influx of explorers and miners that will visit that section of country in the spring. It will be therefore advisable that they furnish themselves with partial supplies, at least, from central points. This there will be no difficulty in doing, as the towns and villages in close proximity will be sure to keep all necessary supplies on hand.

The Gneiss rock, as before stated, being composed of sedimentary matters, are overlaid to a certain extent by another series of rock, which are called the Huronian formation, and is confined to the locality of that name, but it is the former, or Laurentian formation, which is under discussion, and the one with which we are more immediately concerned. The Laurentian strata consists principally of highly crystalline beds of micaceous and hornblendic gneiss; horneblende rock; crystalline limestone, and dolomite; magnesian limestone; oxidized iron ores; quartzite, and anorthosites, or rock composed chiefly of lime and soda feldspar; and to which may now be added native gold in quartz, and decomposed pyrites, and earthy oxyde of iron, in auriferous alluvial deposits. In an economic point of view the Laurentian formation has hitherto been more particularly characterized by the vast beds of magnetic and specular iron ore contained within it full details of which

would be out of place here. Its thickness is unknown, but as what is supposed to be its equivalent in Scotland, is estimated by Sir Roderick Murchison to be 96,000 feet, there is no reason, as yet known, why the Canadian Laurentide rocks should be placed at a lower estimate.

A belt of this formation crosses the St. Lawrence at the thousand Islands, below Kingston, and expands over a large section of country south of that River, in the state of New York, comprising the Adirondack Mountain region, in the State of New York.

From Kingston, as before remarked, this formation strikes in an irregular line through *Madoc*, Marmora, &c., to the head of the Georgian Bay. On the south of this line it is overlaid and flanked by the Lower Silurian strata, which, from its appearance, and horizontal attitude, is easily distinguished from the more corrugated and disturbed Laurentian formation lying to, and flanking it on, the north. The line of contact between these two formations is very irregular. In many instances there are outlying patches of either formation, far removed from the main line of contact, and completely cut off from its own rock bed. These outliers will be easily recognized by the explorer. The contrast is so great that there can be no mistaking them; for, while the one is horizontal, smooth, clean, limestone flags, the other is coarse, corrugated, twisted, and tilted up gneiss, full of quartz veins and mica shales. *It is to the north of this line that the explorer must confine his explorations for the precious and many other valuable mineral substances* to be hereafter mentioned; for to the south there lies a more recent and wholly different formation, in which little or any valuable metallic substances have as yet ever been found.

Far inland, and extending from Labrador through to the North West, there arises a mountain chain, through the central part of this formation. Its most elevated parts range from 100 miles in the East to about 200 miles at Madoc, from the southern margin of the formation. This range of hills is about 2000 feet high. It constitutes the water shed between the great north and south basins of Eastern British America. This mountain chain, stretching from the coast of Labrador, and crossing the continent, to the northern part of the Rocky Mountains, is a perfect terra incognito, and may, like its southern sister rocks, be auriferous and contain metals of very great importance, or not—*it is unknown*—time and exploration alone will determine the fact, and their hidden treasures, like many of the past, may, in the inscrutable wisdom of Providence, remain dormant and undeveloped for the benefit of generations yet to people the earth.

In connection with the above it may be necessary to say a word respecting a more recent formation, covering a large broken area between the western outlet of the French River on Lake Huron, and the head of Lake Superior. This is very appropriately called the Huronian Formation. It more or less overlies the Laurentian

Rocks, between the places mentioned, and extends to the North East, for some considerable distance, from the French River—certainly over 100 miles. It appears to be an *overflow*, and consists chiefly of green and grayish slate conglomerates, and other partially altered strata, interstratified with greenstone masses, and traversed by numerous Trap Dykes. It contains many quartz veins, holding copper pyrites and copper ores, in commercial quantities. It also contains vast deposits of iron ore, of the finest quality. On the whole, it abounds in minerals of great economic importance; but the illiberal policy hitherto pursued by the Government has retarded the progress of development of the great mineral wealth of that region. It is to be hoped a more liberal and less suspicious policy will be adopted under Confederation, when the people of Upper Canada shall have the absolute control of her own land granting department. The total thickness of this formation is probably not much under 20,000, and if it has, as has been suggested by Sir W. Logan, its equivalent in the calciferous and chazy formations of the East, why may that formation not also, on examination, prove auriferous, as well as that of the Eastern Townships? We wil not, however, discuss that matter just now, but pass on for the benefit of the explorer, to the consideration and the possibe identity of those strata and rocks in which *gold* has been found, at Madoc, and other parts of the gold bearing world.

MICA SHALE.

Mica Shale has the constituents of gneiss, but is thin slate, and breaks with a glistening surface, owing to the large proportion of mica, upon which its foliated structure depends. It contains less feldspar and much more mica than gneiss. The thin even slabs of the more compact varieties are much used for flagging, and for door and hearth stones, and for the lining for furnaces. The finer clay or arenacious varieties make good scythe stones. Both these varieties may be found in abundance in convenient positions, for manufacture and transportation, in many parts of the formation under consideration.

Hornblende resembles mica slate but has not so glistening or bright a lustre, and seldom breaks into as thin slabs. It is more tough than mica slate and makes an excellent material for flagging.

Talcose Slate resembles mica slate, but has a more greasy feel, owing to its containing talc instead of mica. It is *usually light gray* or dark grayish-brown. It breaks into thin slabs, but is brittle, yet often makes good firestones, and sometimes it is worked for *scythe* and *honestones*.

Talcose Rock is a hard and tough compact rock, cotaining more or less talc, and often quite compact. It is usually very much intersected by veins of white quartz. Much of it contains chlorite (an olive green mineral) in place of talc, here and there disseminated.

Chloritic Shale has a dark green color, and is similar in general character to talcose slate. *These rocks are to a great extent the gold-bearing rocks of the world, especially the quartzose veins that pervade them.* Platinum, irridosmium, pyrites, and many other minerals, occur in them, or in associate beds.

Steatite is a soft stone, easily cut with the knife, and greasy in its feel. Its color is usually grayish-green, but it is subject to many variations. It occurs in beds, generally associated with talcose slate. *Potstone* is a compact steatite. *Rensselaerite* is another compact variety used for inkstands Neither of these are likely, however, to be found in any great quantity, in a state fit for commercial purposes, in the formation under consideration.

Serpentine is a dark green and other colored, unstratified rock, usually associated with talcose rocks and with granular limestone. The purer varieties are of a rich olive green color, and forms a very handsome marble when polished. It is a silicate of magnesia, or rather magnesian silicate, with traces of protoxyd of iron, carbonic acid, and water.

Trap rock is a dark greenish or brownish rock, heavy and tough. It has sometimes a granular crystilline structure, and at other places it is very compact, without apparent grains. It is an intimate admixture of feldspar and augite. It is often called dolerite. The Feldspar in this rock is usually the kind called *Labradorite—one of the most beautiful minerals known to Canadian geology*, and which occurs in many places in the formation under consideration.

Porphyritic trap, like porphyritic granite, contains disseminated crystals of feldspar.

Porphyry consists mainly of compact feldspar. Red, or brownish red and green, are common colors; but grey and black are occasionally met with. The feldspar crystals are, from a very small size, to half or three quarters of an inch in length, and have a much lighter shade of color than the base, or are quite white. It breaks with a smooth surface and concoidal fracture. Porphyry receives a fine polish, and has been used for columns, vases, mortars, and other purposes. Green porphyry is the *Oriental verde antique* of the ancients, and was held in high esteem. *Red porphyry* is also a beautiful rock. It has a clear brownish red color, and is sprinkled with small spots of white feldspar.

Clinkstone is a grayish blue rock consisting, like porphyry, mainly of feldspar. It passes into gray basalt, and is distinguished by its less specific gravity. It rings like iron when struck with a hammer, and hence its name.

Trachyte is another feldspatic rock, distinguished, by breaking, with a rough surface, and showing less compactness than clinkstone. It sometimes contains crystals of hornblende, mica, or some glassy feldspar mineral. It occurs in volcanic regions.

Slate is an argillaceous rock, breaking into thin laminae.

Shale is a similar rock, with the same structure usually less perfect, and often more brittle.

Schist includes the same variety of rock, but is extended also to those of a much coarser laminated structure. The ordinary clay slate has the same constitution as mica slate; but the material is so fine that the ingredients cannot be distinguished. The two pass into one another insensibly. The colors are very various, and always dull, or but slightly glistening. *Roofing slate* is a finer grained variety, of a dark dull blue, or bluish-black color, or somewhat purplish—Occurs of excellent quality near Danville and Melbourne in Lower Canada, and Thunder Bay, at the head of Lake Superior.

Argilite is the term generally given to all clay slate rocks. *Novaculite, hone slate*, or *whet-stone*, is a fine grained slate, containing considerable quartz, though the grains of this mineral are not perceptible. It occurs of light and dark shades of color, and compact texture.

Alum Shale is any slaty rock which contains decomposing pyrites, and thus will afford alum or *sulphate* of *alumina*, on lixiviation, or leaching, as in making ley.

Plumbaginous schist is a clay slate containing plumbago or graphite, and leaves traces like black lead.

Pipestone. The pipestone of the North American Indians was in part a red clay slate, or compacted slate, from Coteau de Prairies. It is called *Cataline.* A similar material occurs on the north shore of Lake Superior, at Nepigon Bay. Another variety is a dark grayish-green compact argilite, found at the outlet of the bay N. W. from Coldwater, on the Georgian Bay.

Quartz rock is a compact rock, consisting of the oxyd of silica, and often appearing granular. Its prevailing color is white, but is often found passing into gray, reddish, or dull bluish, and sometimes brown. When the granular quartz contains a little mica, it often breaks in slabs, like gneiss or mica slate.

Gold and Topaz are often found in *micaceous granular quartz*, which is one of the most refractory rocks known. It is consequently used extensively for hearth-stones, for the lining of furnaces, and for lime kilns. At Stafford, in Connecticut, a loose grained micaceous quartz rock is highly valued for furnaces, and sells at the quarry for $16 per ton (gold). Another highly important use of this rock is in the manufacture of glass and sand-paper, and in sawing marble, and for the manufacture of hone-stones and whet-stones. In many cases it occurs crumbled to a fine sand, and is then highly convenient for these purposes. Quartz rock occurs

filling veins or fissures, in all formations, but appears to be most abundant in the subcrystalline strata, and particularly the one under consideration. It can easily be traced, where found, along the outcrop of the containing rock, in the form of a white band, which varies from a mere ribbon in width to several hundred feet. *Where these veins are found in contact with any of the slates just mentioned, they should be well searched for gold, and particularly so where either contain iron pyrites or red oxyd of iron (ochre)—i.e., iron in a state of decomposition.* If the *bisulphuret* of iron (pyrites) is the true matrix of gold, and there are grounds for believing that such may be the case, where these pyrites are exposed, they become decomposed and changed by absorbing or taking up another equivalent of oxygen from the atmosphere, whereby it becomes pulverulent and soluble sulphate of iron, or the common copperas of commerce. If the iron pyrites contain any gold (and it is seldom, if ever, found without traces of it) it will remain unaffected by such change, and become deposited and drifted about in the place where the decomposing pyrites exist. Pyrites are often partially or wholly decomposed at a considerable distance beneath the surface, when the rocky structure is cavernous or loosely stratified. This is caused by the action of the oxygen, contained in the waters permeating the strata, coming in contact with the pyrites, and changing it into a soluble sulphate, when all traces of it may be washed away with the permeating waters, and the precious mineral (gold) they contain left behind. Or, the waters which permeate the strata, generally carry with it from the surface, some vegetable acid, from decomposing vegetable matter. This water, after penetrating some distance beneath the surface, and carrying with it this acid, naturally follows along the stratification of the rocky structure of the country, passing over and coming in contact with deposits of iron, which the acid contained in the water immediately attacks and dissolves, carrying it along till it makes its exit at some lower level, where, coming in contact with the oxygen of the atmosphere, it becomes oxydized and precipitated from its solution, and changed into the peroxyd of iron, or what is commonly called *yellow* and *red ochres*. In either case, neither the acid nor the atmosphere will have any effect on the precious metal that may be contained in the pyriteous ore, and it will be left behind as a deposit in the place from whence its matrix was so removed. This is a process that has been constantly going on through all ages, and is yet in full but silent play over many parts of Canada and particularly in Lower Canada, as witness the vast deposits of peroxyd of iron that are still in the process of formation there. Such may probably have been the process whereby many of the "pockets" of gold that are found beneath the strata have been deposited.

We shall now proceed to furnish a short account of the minerals that occur and are likely to be met with in the formation under

consideration, so that the explorer, while traversing that region in search of the more precious metal, may also have an eye to the discovery of other minerals of equal, if not of greater importance, than the auriferous deposits that are now known, beyond a question of doubt, to exist in the very extensive Laurentian gold fields of Canada. And, in the first place, we may remark that, as the foregoing rocks are likely to be met with, sparingly, in that formation, a short description of them is deemed necessary for the guidance of the explorer, more particularly as they are all more or less associated with the gold fields of other countries. In the second place, we may be allowed to preface what follows by a few general remarks on the geographical distribution, origin, and position of minerals; the nature and depth of the veins and faults.

Alluvium signifies recent deposits of matter, and comprises sand, gravel, loam, and clay. It sometimes contains, or is almost entirely composed of animal remains It is found nearly all over the country, along the sea coast, the lakes, rivers, and rivulets, and forms their banks and bottom. Bog iron ore, peroxyd of iron, (ochre) potters clay, fire clay, peat, and a few others are its only productions in a commercial point of view.

Minerals are chiefly distributed over and below the surface of the earth in layers or masses, in lodes, or large veins, running parallel with or traversing the general course of the stratification of the rock, in nests or pockets, in nodules, which are concretions or accumulations of minerals of small extent, intimately diffused through the containing rock, and in small veins, which are either branches of heavy rock, or traversing larger veins, ramifying the rock in all directions.

The Laurentian formation, being a low subcrystalline and metamorphic series of rocks, resting immediately upon the primitive rocks, and, being composed of their disintegrated atoms, in a highly altered condition, together with those other and immediately succeeding formations, which may have, like the former, been subjected to violent uplifting, long continued heat, and metamorphic action, whereby their physical properties and character have become very much changed, may be considered the *home* of the greater part of the more valuable mineral and metallic deposits of the world. In these metamorphic or highly changed rocks, we find more variety and greater abundance than in any undistributed equivalent of the same or succeeding geological formations. In these rocks the best qualities and greatest abundance of ores are always found. The rocks of a higher series, or those which contain bituminous coal do not furnish anything like so great a variety, or quantity of minerals, as these metamorphic rocks, and many kinds are not found at all in them. They do not furnish gold, copper, antimony, and many other substances. They chiefly furnish coal,

iron, limestone, with lead and zinc sparingly, and in very limited quantity.

Mineral substances, particularly those which are used for the production of metals, *i.e.*, the workable mercantile or common useful ores, are very few in number, and are generally oxyds, that is, combinations of metal with oxygen; sulphurets, or metals combined with sulphur, and carbonates; or metallic oxyds combined with carbonic acid. Combinations of metals with other substances than this there are, but they are rare.

The above description of minerals frequently form large bodies, or masses of pure ore, by themselves, buried beneath the surface of the rock. They are generally, however, blended and mixed with foreign matter as lumps or grains of quartz, lime, and other substances, such as baryta, c[illegible]per, &c., which are either mechanically mixed or in chemical [illegible]bination with them. Sometimes the main body of the vein is [illegible]nd to be rocky matter consisting of the matrix or ore veins, and the ore sparingly imbedded in that substance. Indeed this is the case in ninety-nine cases out of one hundred. Again, the mineral masses are found, in that one exceptional case in the hundred, in such heavy hard masses as to admit of their extraction without any admixture of the veinstone or wall rock. In other cases rock and mineral cannot be raised together before separation. In other and the far greater number of instances, the veins are too small for the entrance of the workmen, and are consequently of no value, unless it should happen to be some of the more precious metals or minerals, when the value of the mineral lode might justify the expense of blasting away the wall rock and making a larger opening.

Geographical distribution of minerals. We have already briefly stated our views of the general geographical distribution of the great majority of the more valuable mineral bodies, but as our readers may desire to know something of our views of their geographical distribution on this continent, and more particularly in reference to Canada, we will briefly state that there is indubitable evidence that the Laurentian rocks are the oldest on this continent. They were thrown up from beneath the ancient sea, from the coast of Labrador to the extreme north end of the Rocky Mountains, at the Arctic ocean, an extended distance of about 5,000 miles. In this position they remained, as an island, and the nucleus of this continent for countless ages. In the mean time sedimentary matter was being washed down and accumulated in the bed of the surrounding oceanic waters, when, in the process of time, another upheaving took place. This upheaval, radiating from the same point in the extreme north east part of the Province, from whence the Laurentides received their impetus, struck off in a south westerly direction, upraising the southern portion of the continent of North America with its superincumbent, and far more recent de-

posits, as evidenced to this day; thus forming the Allegany chain of mountains. Here we have two great mountain chains radiating from the same point, and bearing off in different directions in all their solitude, through the trackless ocean for thousands of miles. These two mountain chains, diverging, and, opening to the west, formed two sides of an open triangle, facing to the west, and having the western, or Pacific, ocean rolling in between them. After another long period in duration, another great convulsion of nature took place, and up came the Rocky Mountains, and the Andes of South America, with their more recently accumulated sedimentary matter, thus shutting in and forming a great triangular inland sea, to be afterwards filled up with the detrital matter from the walls of this great surrounding or enclosing triangle. Such, I presume, has been the nucleus and formation of our great North American continent.

Now, if we run our eyes over the map of the continent, we will see that there are three great mountain ranges, such as I have above described. The Laurentian is the oldest; the Allegany the second, and the Rocky Mountains the latest. In truth we know that for a long series of years the southern chain, or Alleganies, produced very large deposits of gold and other precious metals, and that the gold bearing land has been traced and successfully worked through that chain for upwards of 1,000 miles—the Eastern townships gold fields belong to this chain. We also know that the Rocky Mountains, from California, and far south of it along that chain, to far north of British Columbia, is a gold bearing range, and is also rich in various mineral deposits; and why not the other and older member of this sisterhood be also a gold and rich mineral producing region? Why should she be deprived of the inheritance, custody, or share of the precious metal, because she is more aged? Briefly, and to the point, there is more reason why our Laurentide mountains should be a gold bearing region than those of either the Alleganies or the Rocky Mountains, for it is generally admitted that the precious metal is confined to the lower subcrystalline strata. We may search in vain for a lower crystalline strata than that found in the Laurentide Mountains. But it may be asked, how comes it that the precious metal is found in the Rocky Mountains, and in the Alleganies, when they are overlaid by a more recent formation? The answer is that, either the lower and more primitive rocks have been brought up by the forces that elevated those regions, or that the long continued and powerful heat to which their secondary strata was subjected, during their elevation, changed them by metamorphic action, and rendered them also, as before stated, mineral and metallic-bearing rocks, of the first order.

The origin of minerals in veins may be mainly considered the result of infiltration from the surface, to which class many of the copper and iron ores belong. In some instances it is probable

that deposits have been formed at the bottom of the ancient seas, as those of the coal measures, while others may have been ejected from below, and raised by the power of internal heat, and some caused by the electro magnetic current. The first class generally consists of wedges decreasing with the depth; the second of spheroidal masses, and the third of wedge-shaped masses increasing with the depth. The first class of veins is the most deceptive, and cannot be depended upon; the second can be estimated by its appearance on the surface, or by sinking shafts into it; the third class may be depended upon as increasing and improving with the depth.

Mineral veins are not always found in a horizontal position. The stratification of the Laurentian rocks is very irregular, and much contorted. It would be a difficult matter in that region to follow the stratified edges of the upturned rocks for any considerable distance. These rocks dip at almost all possible angles. Those veins which were formed before or while this great field was in a state of violent agitation will be difficult to trace out, while those which were formed at a more recent date, after the agitation ceased, will be comparatively easy. There are two sets of quartz veins pervading this formation, (at least in some parts of it) for one set strikes north-east and south-west, while the other crosses it on the opposite points of the compass. The strike of a rock is the direction that its upturned edge bears to the compass. The Laurentian rocks are, in many instances, almost vertical, and generally inclined, not less than 30° to 75°. The inclination or dip of a vein or rock is measured from the horizontal plane. If, therefore, a vein dips but 10° it is nearly horizontal, and if it dips 80° it is almost vertical. The dip of a vein is not always uniform in its various parts, particularly if the plane of the vein is not parallel to the plane of the statification.

The depth of veins. It is almost impossible to determine the depth of veins when they are not horizontal. Indeed, we have no such thing as a really horizontal fissure or vein, (though some minerals are deposited horizontally) because they have been openings caused by internal volcanic action from below, and therefore reach to an enormous depth. These fissures, or rents, were subsequently filled up, most generally, by silica held in solution in the waters that covered the face of the deep when they were formed—hence the origin of quartz veins.

The mining operations in this country are of such a recent date, that there has been hitherto neither time nor necessity for deep mining. We cannot, therefore, say to what depth they extend, nor is it at all probable that their ultimate depth will ever be reached by the art of man, either in this or any other country. There are very few mines more than three hundred feet deep in the United States. In Germany they have been sunk to the depth of two thousand six hundred feet. In Mexico one thousand six hundred

and fifty feet. The tin and copper mines of Cornwall, in England, are one thousand eight hundred feet deep, and the silver mines of Norway, Saxony, and Hungary, are of about equal depth.

Veins of Minerals are often found to be disturbed in their regular course, either by other mineral veins or, by dead rock. These are called *faults*, slips, or slides, and appear in every kind of vein. They are caused by matter which has penetrated the crevices of the rock, after the fissure was opened. The mass of a vein is often found to divide into various small branches, which, at certain distances, or at greater depths, re-unite. Such faults, whether consisting of mineral or dead veins, are often very perplexing to the practical workmen, but the scientific miner is never at a loss in such cases.

Gold.—We shall now pursue our remarks on the gold formation of *Madoc*, and the Townships to the east and west thereof, lying north of the line of junction between the Laurentian and the Lower Silurian formations, as they appear at the present moment to be the great centre of attraction; and this is the locality in which the precious metal has so far been found in the greatest abundance, though other townships and localities, a considerable distance to the North, to the West, and to the East, all in the Laurentian formation, have reported the discovery of auriferous deposits, of very great richness and magnitude, both in the quartz, oxyd of iron, and alluvial washings, certainly some of the quartz specimens are exceedingly rich; and, if one tenth part of the paper and other reports prove correct, we may congratulate ourselves as being possessed of one of the largest and richest gold bearing countries in the world.

Even in the depth of a Canadian winter (1866–7) many have struck out, and, notwithstanding the great depth of snow, and the severity of the weather, have succeeded in unearthing some fine rich specimens of the precious metal.

The gold in this region is not confined, as is mostly the case in other gold bearing countries, to alluvial washings, but is found in the native quartz rock, in the alluvial washings, in the ocherous matter, and in the large beds of black magnetic oxyd of iron, (commonly called *black sand*) that is so abundant in that formation. The writer travelled over a good deal of this gold bearing formation in 1863–4, and found the precious metal, in both years at several points about 100 miles, a little, west of North, from Madoc. This fact, coupled with the current reports of its discovery in various localities, far apart, and in intermediate places, goes to confirm the view that the precious metal is not confined to any one isolated spot, or small section of country, but, as I have already said, extends over a large area of country, and to an unknown distance, both to the East, to the West, and to the North; and why not? This (the Laurentian) is the largest formation on the continent, and, so far as observations have been

able to determine, is identically the same, in all its parts, and over all its whole area. The specimens of gold bearing quartz from our Laurentide rocks are decidedly rich in gold. They appear to be literally studded with pieces of gold, varying in size, from that of a grain of powder, to that of a pea, and which, at a reasonable estimate, would be worth $2000 to the bushel or 100 lbs. quartz. Besides these quartz specimens, the alluvial washings, oxyds of iron, and ochreous matter, are stated to be exceedingly rich. Certainly the pieces exhibited, as coming from the washings in that formation, are large and of the most encouraging description.

There are several main lines of Government roads leading into this formation for some considerable distance, which will be good starting points for extended lines of exploration; and their connection with the frontier, at short distances, where the Grand Trunk R. R. and Steamers, are passing almost every hour in the day, affords facilities for carrying on explorations, and prosecuting mining enterprise, unparallelled and unprecedented, in the annals of the gold mining world.

These main lines of road, traversing that formation, are the Oppiongo, starting from the city of Ottawa, and striking toward Lake Nippising, is finished to Oppiongo lake; the Hastings Road running from Belleville, on the G. T. R. R., through Madoc, in the County of Hastings, and intersecting the former near Oppiongo Lake; the Bobcaygeon and Trading Lake Road, starting from Peterboro, a R. R. Station, connecting with the G. T. R. R. at Port Hope, and terminating 12 miles beyond the cedar narrows, at Trading Lake; the Victoria Road, starting from Lindsay and Beaverton, and intersecting the Peterson road, in the Township of Oakley, near the Muskoka River, and which latter (Peterson Road) runs from the Oppiongo Road via Wabushkong Lake, intersecting the Burlington and all the other lines of road before mentioned to Muskoka Lake; the Muskoka Road from the foot of Lake Conchiching to Muskoka (20 miles) Parry sound and Vernon Lake, connected by Railroad and Steamer with Toronto. There are three other lines of road running through the counties of Addington and Frontenac, and known by the name of the Mississippi, Frontenac and Addington roads. From all these points on the frontier, the explorer will find no difficulty in taking his supplies and reaching any part of the gold bearing formation, he may desire, between the Ottawa River and the Georgian Bay; and when he reaches the distant haven, he will find along its frontier a scattering but civilized population, and many facilities both by streams, lakes and otherwise, for the removal of his camp equipage, from place to place, and the keeping up of his supplies from the outer world. But let him not neglect his supply of fish-hooks and his dog and gun, as that country literally abounds in fish and game of the finest quality. There he will find brook trout weighing from 5 to 7 pounds, and

black bear weighing 200 to 300 lbs., and venison and other game without number. These he must salt for 24 hours, then smoke well, and pack for future use.

To strangers coming into the country, I would say secure the author's maps of the gold fields, his geology and minerals of Canada, and the present work, and read and study them well, and the services of a good Canadian to accompany you. When I say a good Canadian, I mean one that is accustomed to the bush and the canoe. Encumber yourself with as little as you possibly can. Throw away, or leave behind, all superfluities; for, unless you penetrate very far back, you will at all times be within a day or two of plenty of supplies. Five or six joining together, and procuring a tent made of light twilled cotton, a couple of canoes to examine around the small lakes and rivers, which are very numerous, a couple of bags of flour, a couple of hundred weight of dried fat pork, some tea, coffee, sugar and salt, one blanket and musquito bar, and a little rock oil for each, a couple of small axes or tommahawks, fish-lines and trolling spoons, a small gill net, a double-barrelled gun, with powder and shot; a few bullets, or buckshot; a frying pan, soup pot, and tea pot, with a tin plate, knife, fork and spoon, for each man, and a packing basket to carry them in, with a couple of empty water proof sacks, in which to pack dried meat and fish, and a small pocket compass. For mining operations it will also be necessary to take a washing pan for each man, a couple of iron ladles, a keg of coarse blasting powder, a few yards of patent fuse, a couple of steel drills, (one two, and one four feet long) a miner's pick-hammer, a good pocket lens each, two good strong striking steel hammers, a scraping rod, a small glass-stoppered phial of each of the acids—hydrocloric, nitric, and sulphuric—and two or three pounds of *pure* and *unalloyed* mercury, and a piece of good chamois leather or buckskin, through which to press the mercurial amalgum, and save the mercury after it has passed through the alluvial washings, where the existence of gold is suspected in the sands and gravel. To the above might advantageously be added a quart cast iron pestle and mortar, to crush and test the quartz.

The gold in the region under consideration will be found in its native state, in small grains, in spangles, in crystals so small as to be almost invisible to the naked eye, and also in large grains and lumps. It will also be found imbedded in masses in quartz, particularly that which traverses talcose or chloritic slate; at other places it will be found mechanically enclosed by quartz and decomposed pyrites, or ochreous matter. It has not as yet, I believe, been ascertained whether the native gold of the Canadian gold fields is pure or alloyed with silver uranum, &c., &c.

The admixture of silver in the California gold, which has hitherto been almost exclusively found in the alluvial sands and gravels on the banks of the rivers, and in the valleys and gulches

traversed by mountain streams, diminishes its value 15 to 20 per cent.

The implement used for washing out gold is very simple and consists of a sheet iron or tin pan, ten to twelve inches in diameter, and three to five inches deep. It will not do to put mercury in a *tin pan*, as it will adhere to the tin, and the mercury be lost; nor will it do to put mercury in a *greasy pan*, as the grease will adhere to and coat the mercury, and prevent it taking up the gold. If any greasy substance has been used in the iron wash pan, it must be well burned and cleaned out before using mercury in it, or you will lose your labor, and leave any gold there may be in the pan behind. When the place for prospecting has been fixed upon, the pan is filled with the suspected sand or gravel, immersed in water and shaken, when the gold, if any, sinks to the bottom, and the sand, clay, and gravel on the top flow off with the water, or are taken out by hand, till the bulk in the pan is reduced to less than a handful, which may be examined by the eye glass and put into a *clean* dish, and the operation continued till there is sufficient collected—say two quarts—to run the mercury through it. The material so obtained may then be placed in a clean iron pan, *free from grease*, and say half a pound of clean mercury poured in, immersed or filled with water, and thoroughly mixed, stirred, and shaken till the mercury becomes intimately diffused in minute particles throughout the whole mass. When this is done a few minutes dexterous shaking of the pan in the proper position, which a little practice will soon make perfect, the operator will be enabled from its great specific gravity, to concentrate and bring the mercury and gold amalgam to the bottom, and thence to one of the sharp edges of the pan, from which it can be poured into a clean iron dish, thence into a piece of buckskin or chamois leather, and the mercury forced through its pores into a clean vessel and saved, when, if there be any gold in the material under examination, *it will be held in the leather in the form of a white, silvery, soft mass.* If this amalgam be now placed in a clean iron ladle, and over a hot fire till the ladle attains to a red heat, the mercury will be thrown off and the gold left behind. It cannot be doubted that a large quantity of gold is lost in this way, but as my object is to furnish the most simple and practical general information as a guide to the explorer, both geologically and geographically, and the most simple tests whereby he may easily and readily determine the character and quality of the minerals which he may find, I do not deem it expedient, in a synopsis of this nature, to speak of the more perfect and expensive modes, and the improved machinery and appliances in use in other countries, necessary to the successful development and extraction of the precious, or any other mineral, from its native bed. Suffice it to say that the above is a good, sure and simple test, which can be determined by the most inexperienced, and that the proximity

of the Canadian gold fields to all the commercial facilities of the world, affords unparallelled advantages for the cheap and easy introduction of all and every of the most approved modern appliances for the extraction and successful working of the great mineral deposits of the country, be they gold, iron, or otherwise.

It is more than probable that the gold bearing rocks of the Laurentian formation will be found, as before stated, to be some one or more of those of a shaly or slaty character that are intersected by quartz veins—probably *chloritic and talcose* slate. The latter resembles soapstone, but it is not so greasy to the feel, and the former has a dark green color, and is similar in general character to talcose slate. *It is the quartz veins that traverse these shales we should particularly examine for gold, auriferous pyrites, platinum, &c.* When a place has been selected for trial, a two or three feet deep blast may be blown out, and if the gold is visible and it is desired to test the quality of rock, take about one pound and pulverize it, and grind it very fine in an iron mortar, wash it and treat with mercury in the same manner as directed for the washing and testing of sand and gravel, and the weight of gold produced in the pound will give the ratio per ton of rock. When the *quartz are wanting* in these rocks, very little gold may be looked for. These shales are sometimes found colored red at and near the surface. At a greater depth they are filled with small crystals of iron pyrites, which are decomposed near the surface, and appear as peroxyd of iron, or ochre, which colors the slate brown, and in some instances yellow. This is a sort of metamorphic rock of various degrees of hardness, and, where it has not been subsequently disturbed, runs in regular belts, generally parallel with the stratification of the formation in which it is enclosed. Those parts of the band which are usually richest in gold, are generally characterized by small veins of quartz running parallel with the slate, and when this quartz is wanting very little gold is to be expected. The talcose gold-bearing slate of Gold Hill, in North Carolina, is particularly distinguished in this respect; and it may be said that the ores from that mine are the richest of that whole gold region. The direction of the veins is parallel to the general course of the strata or formation; that is, from north east to south west, and their inclination or dip, which is also parallel to that of the strata, is from 45° to 90°. In their extension, these beds of slate rock often become changed in their composition, and pass into feldspar, mica shale, and other relative rocks, when they cease to be auriferous, or to contain gold-bearing quartz. The quartz veins that run through these shale rocks are often very large, and sometimes found to contain galena, iron, copper, and bisulphuret of iron, or pyrites, which in themselves again are occasionly found to be rich in the precious metal. It is said the gold found in the slate rocks of Virginia and North Carolina occurs in exceedingly small grains, often so fine as to be not only

invisible to the naked eye, but undiscernible even by the assistance of a strong lens; and this is the case even when the rock ores are worth three or four dollars per bushel. Some of the veins of that region contain course gold, in grains as large as the head of a pin, and even larger, which are generally found in quartz in which pyrites are concentrated into larger masses. When the pyrites are disseminated in fine crystals through the mass of the rock, the gold is found to be very fine. In fresh pyrites the gold (being of the same color) is invisible, even if after separation it appears to be coarse. Gold is easily distinguished from pyrites. It is malleable and soft, and easily beat out with the hammer, or cut with a knife, and will form an amalgam with mercury. *Pyrites* are easily distinguished from gold. By natural or artificial decomposition the gold becomes visible; the pyrites are converted into the oxyd, or solnble sulphate of iron, and by the aid of a lens the gold may be detected.

Iron pyrites—Bisulphuret of iron. Usually in cubes, simple or modified. Its color is bronze yellow, with a lustre often splendent metalic. It is very hard and brittle, and will strike fire with steel. Its composition is iron 47 per cent., and sulphur 53 parts in one hundred. They are distinguished by their cubical form, and in being too hard to be cut by a knife—copper being much softer, and not hard enough to scratch glass, or strike fire with steel. Iron pyrites occur in rocks of all ages, and is one of the most common ores on the globe. The ores of *silver* at all approaching pyrites, are steel gray, or nearly black, and are easily cut with a knife, and quite fusible. Gold, though much resembling it in color, is soft and malleable, and does not give off a sulphur odor before the blow-pipe, or on hot iron, like pyrites. This species of ore is of the highest importance in the arts, although not affording good iron, on account of not being able to entirely separate the sulphur from it. It affords the greater part of the sulphate of iron (green vitriol or copperas) and sulphuric acid (oil of vitriol) and also a considerable portion of the sulphur and alum of commerce. To obtain the sulphur, the pyrites are sometimes heated in clay retorts, by which means about 15 to 20 per cent. of the sulphur is distilled over and collected. The ore is then thrown out into heaps, exposed to the atmosphere, when a change ensues, by which the remaining sulphur and acid become sulphuric acid and oxyd of iron, and form sulphate of iron, or copperas. The metal is then lixiviated or leached, and partly evaporated, and run off into troughs or vats to crystallize. In other instances, when the sulphur is not sought to be obtained, the ore is coarsely broken up and piled in heaps and moistened. Fuel is sometimes used to hasten or commence the process, which, afterwards, the heat generated continues, and decomposition takes place as before mentioned, with the same result. One manufactory at Stratford, in Vermont, produces about 1,000 tons of coperas annually, which at

2 cents per pound, produces $40,000 per annum. The great use however, to which iron pyrites are applied, at the present time, is in the manufacture of the sulphuric acid. It is found to be an easy matter to calcine or roast the iron pyrites in a furnace of a peculiar construction, and by this means expel almost the whole of the sulphur in the form of sulphurous acid, which is conducted at once to leaden chambers, the floors of which are covered with water, which, by the absorption of the sulphurous acid and another equivalent of oxygen, at the expense of a very small quantity of nitric acid, becomes converted into sulphuric acid. Formerly large quantities of sulphur were imported into Britain for this manufacture, but within the last few years it has almost entirely been replaced by pyrites, which is brought in large quantities from Spain, Portugal, Belgium, and Ireland. It is stated that the consumption of pyrites in Britain for the year 1862, for the manufacture of sulphuric acid, reached 264,000 tons, which, at $10 per ton, amounts to $2,640,000; and this took place before the manufacture and exportation of such vast quantities of sulphuric acid as have found a ready market at the oil refineries of the United States and Canada. In order to give some idea of the great importance of the vast deposits of iron pyrites and its products, that occur in Canada in a commercial and manufacturing point of view, I may state that sulphuric acid, which is now for the most part manufactured from pyrites, is the agent used for decomposing common salt for the manufacture of soda, in its various forms of soda-ash, carbonate of soda, and caustic soda. From this decomposition is also obtained hydrochloric acid, which is used in the manufacture of Chlorine, and chlorid of lime,—materials indispensible in the manufacture of paper and in the bleaching of cotton linen, &c. Besides this, the manufacture of soap and glass, and many other chemical products, are dependent upon the soda thus obtained. Sulphuric acid is also used for the manufacture of nitric acid, superphosphate of lime, alum, and many other products; all of which are generally manufactured in the vicinity of sulphuric acid and alkali works. The value of the products of the alkali manufacture in Britain in 1860, is stated to have been £2,500,000 sterling, or $12,500,000. Of this about $5,000,000 was manufactured in South Lancashire, where 3,110 tons of sulphuric acid are consumed every week, for the decomposition of 2,600 tons of salt. Besides this 700 tons of the acid are employed for other purposes, making a weekly total of 3,810 tons of sulphuric acid manufactured in that district alone; the greater part of this from pyrites. These statistics will serve to show the immense importance to a manufacturing country, of an abundant source of sulphur. The time will come, and is even now at hand, when our increasing industry will be sufficient to open our eyes and warrant the establishment in Canada of manufactures of chemical products, when the great value and importance of our extensive Canadian deposits of iron pyrites

will be appreciated and converted into useful articles of commerce.

Besides the above there is another—*magnetic pyrites*—which is nearly of the same color as the last, and is generally massive or hexagonal and tubular; it is liable to speedy tarnish, and is slightly attracted by the magnet. *Composition:* Sulphur, 39.5, iron, 60.5, in 100 parts. Its inferior hardness (4) and magnetic quality will distinguish it from the other, and its paleness of color, from copper pyrites. Its uses are the same as the common pyrites.

The great commercial importance attached to an abundant supply of this mineral, (such a supply as Canada will some day afford) in a manufacturing point of view, coupled with the further probability of their being auriferous, besides containing nickel and cobalt, I have deemed it of the greatest importance, that their abundant occurrence, in the Laurentian formation, and the mode of converting them into profitable mercantile commodities, should be made fully known. For, if they should prove to contain either gold, nickel, or cobalt, or all three, which is often the case, in commercial quantities, the usual chemical process before mentioned will have to be applied to extract them, when a conversion of the ore into copperas or sulphuric acid can be effected, at about the same, or at most, very little additional trouble, or expense.

The above is a digression, but the subject is of such importance and the two minerals are so intimately related and connected that I thought it best to introduce the subject in the midst of our remarks on gold, where it would stand a chance of being read, and receive a share of that attention which its importance demands.

Gold never appears in solid veins, but is always disseminated through the mass of the rocky vein. In some places it is not visible, and in others it is quite apparent, while, in exceptional cases, it is obtained in comparatively large pieces. Gold is never found as high in the geological horizon, as the coal strata; nor in any intermediate older formation between that and the gneiss, unless, they have been subjected to great convulsions and physical changes such as the Alleghanies and the Rocky mountains. We may look for it in vain on the level and undisturbed strata of Southern Canada or the Western States, south of the line of junction between the Laurentian and the Silurian formations. It is not there, nor can it exist there. Its origin appears to be in the most ancient rocks known, and is frequently and abundantly found in trap-rocks, or those of igneous origin. *Green-stone-porphyry*, *Syenite*, and *Gneiss*, appear to be the primary sources of gold. The Laurentian or gold formation of Canada, is *gneiss*, with occasional trap-dykes of *porphyry* and *syenite*; these are also found in dykes and veins in other gold-bearing countries. The immediate matrix or vein stone of gold, in some of these regions, is evidently the pyrites which, however, may only be a secondary enclosure, and this view seems to be supported by the fact that some of the richest gold

ores have been found near a vein of trap rock, or other intrusive or igneous strata. Our Canadian gold discoveries now being developed on such an extensive scale, are of too recent a date to have afforded me an opportunity of again so minutely investigating them as would have been desirable.

It is the general impression, when gold is found in the bottom of a stream, or near its banks, or in alluvial soil, that a *vein of gold ore* must exist somewhere above the place where the gold has been found. This impression, however plausible, is fallacious. We find gold in grains disseminated through granite, and also meet with gold in washings in the alluvial deposits of granitic mountains; still there are no gold bearing veins found in the rock. Transition rocks contain spangles and grains of gold, but more commonly veins in which the gold is associated with quartz or calcspar, but more frequently with pyrites. The primary source of gold is evidently in granite and its associated rocks; and the presence of coarse gold in the igneous or volcanic rocks may be attributed to a coagulation of the small particles in its primary sources. These particles belong to the mass of the rock and not to veins located in it. The veins formed in these, and in all rocks, must be secondary to the rocks themselves; and, as such, have been either infiltrated from above, or injected from below. The infiltrated veins can only consist of quartz, feldspar, calcspar, and similar infiltrations which may contain gold accidentally washed into the vein. Pyrites and all other sulphurets of metals appear to be injections from below, as it is very doubtful whether these can crystalize from a watery solution. These sulphurets have, most likely, been driven into the crevices of the rock, either in the form of vapours, which is most probable, or have been injected in masses by pressure from below. Hence we are not justified in expecting veins of gold to exist in the neighborhood of alluvial deposits in which that metal may be found. On the contrary, such a supposition appears quite improbable; for the gold from pyritous veins—the probable true source of that metal—is generally very fine and is most likely to be carried off by the waters. It is an established fact, that where the gold in the alluvial washings is coarse, the chances are that there are no regular veins of gold ore near. Coarse gold is mostly found to have been distributed through the mass of the vein. When a stream contains more gold after a heavy rain or freshet, or where the gold in an alluvial deposit is found in a stratum, it is an indication of there being no vein. The abrasion of the rock furnishes the metal. A severe winter or a heavy freshet is the cause of the formation of this stratum. A vein would furnish a regular supply, but not form a stratum of fine dust. Gold is never carried far from its original resting place; therefore a vein cannot be found at any considerable distance from the alluvial washings, nor is there any prospect of finding it where the river ceases to carry it. The quantity of gold obtained from this

source may be very promising at first, but experience has rendered its future continuance very problematical. It is pretty generally believed that the source of gold in California and British Columbia is in the masses of rock, and it would be well if our Canadian explorers would pay some little attention to these facts.

The next deposit and source of gold may be found in infiltrated veins. Gold enclosed in crystalized quartz is evidently derived from alluvial soil, which has been washed into the crevices of the rock and afterwards covered by quartz in solution; and to this result the heat of a volcanic region has, no doubt, greatly contributed. Silica or quartz is easily soluble in pure hot water, but is precipitated from it as soon as it comes in contact with any other matter, or when cooled.

The veins injected from below are a third source of gold. To these belong the pyritous veins, and as far as their decomposition is concerned, the ferruginous or iron-bearing veins. Whether the gold in these veins is in a metallic form, and has been evaporated in that state, or whether the gold was raised and condensed along with other metals and sulphurets, is a question of no importance as affecting our object, and may be left to the free discussion of the learned. It may, however, be asserted as a fact, that all native sulphurets, particularly all the sulphurets of iron, contain gold. It does not by any means follow from this that all pyrites contain sufficient gold to pay for its extraction. As sulphurets cannot possibly penetrate any rock but from below, we may naturally conclude that the heaviest body, or greatest quantity of such kind of ore must necessarily be deep in the rocky structure of the earth's surface. The conclusion is supported and confirmed by practice; for all pyriteous veins are invariably found to improve in quality and quantity with the depth. Should the veins of pyrites that pervade our Canadian gold fields prove auriferous, as I have no doubt they will, this circumstance will speak very favorably for the permanency and continuous yield of gold contained in them, as we have here deposits of pyrites of almost unparalleled extent, great width, and undoubtedly reaching to, if not far into the primitive rock, a depth of many thousand feet. Here then (if those veins prove auriferous) we have a mass of precious metal enclosed in these veins which cannot be exhausted for ages, and in this respect the region in question is the most important of all the deposits in the world.

From what has already been stated, we may conclude that the *sources* of gold decide the value of a mining region, and if this be the true measure whereby a gold-bearing district is estimated, then there is good reason to believe that the Canada gold fields contain the precious metal in most, if not all the states and positions we have been endeavouring to describe. The gold derived from the abrasion or wearing away of the rocks, where the metal is promis-

cuously disseminated, is the cheapest, if in sufficient quantity and tolerably coarse. The first miners or successful explorers who may arrive at a virgin deposit, may make a fortune in a short time; but when the gold at that spot is exhausted, there is no vein to fall back upon, and a long series of years, nay ages, may elapse, before another heavy deposit of metal is accumulated. If the washings in such districts are not carried on too extensively, a regular yearly supply may be depended upon; the crop being in proportion to the quantity of rain that falls, the severity of the frost, and the abrading action of the atmosphere on the containing rock.

The yield of gold from its containing ore is very uncertain and very variable. In alluvial deposits, a fortune may sometimes be obtained from a pailful of sand. More than one of the gold bearing countries have produced lumps of native gold worth over $6000. The gold ores of the Southern States, that is the iron-bearing slate, either oxydized or pyriteous, now long worked, yield from ten cents to one hundred dollars per bushel. The Nova Scotia gold mines yield from ¼ an oz. to 3½ ozs. to the ton of quartz. Oxydized ore which yields fifteen cents worth of gold to the bushel, pays very well for extracting. Ores which yield but ten cents' worth to the bushel are worked to advantage. Most of the mines, however, yield from twenty-five to thirty cents worth of gold per hundred pounds or bushel of ore; some, however, yields as high as one dollar per bushel. In crushing, washing, and amalgamating or mixing with mercury gold bearing rock, a large proportion of the gold is wasted, which, in very poor ores, amounts to 50 per cent. Ores which yield twenty cents worth of gold by amalgamation, yield forty cents by smelting them. The undecomposed ores are troublesome to work. The way adapted to obtain all or most of the gold is to amalgamate the ore at different times, with intervals for decomposition by exposure to the air. I mean iron bearing, or pyriteous ores.

Burhstone is a quartz rock containing cellules, or small cavities. It is as hard and firm as quartz crystal, and owes its peculiar value to this quality and the cellules which gives it a very rough surface. In the best millstones the cavities are about equal in space to the solid part. The Paris burhstone is from the tertiary formation, and is therefore of much more recent origin than the quartz rock of the Laurentian strata, nevertheless good quartz rock, suitable for millstones, have been found in the latter formation, particularly on the east side of the Ottawa River.

Sandstones consist of small grains of aggregated quartz sand pressed into a compact rock. They have a harsh rough feel, and every dull shade of color from white to yellow, red, brown, and black, and usually consist of silicious sand, with, sometimes, grains of feldspar and a little clay. They are of all geological ages, from

the lower Silurian to the most recent period, and are, therefore, not to be found in the Laurentian formation, but may, in abundance, along its southern margin. The uses of sandstone as a building material is well known. For this purpose it should be free, like granite, from pyrites or iron sand, as these rust and disfigure the structure. Some sandstones, especially those which contain clay, appear well in the quarry, but when exposed for a while, and left to dry, they gradually fall to pieces. This character of rock answers well for structures beneath water, where it is confined from the distructive action of the atmosphere. Some sandstones, which are so soft as to be cut from their bed without blasting, harden on exposure, and are very durable. These are qualities which must be tested before the stone is used. It should also be considered that in severe frosty climates, a weak absorbent stone is liable to be destroyed in a comparatively short space of time, while in a drier and more congenial clime, even sun dried bricks, will last for centuries. Such was the care of the ancients to provide strong and durable materials for their public edifices, that, but for the desolating hand of modern barbarians, in peace and in war, most of the temples and other public monuments of Greece and Rome would have remained perfect at the present day, uninjured by the elements during 2000 years. The contrast in this respect, of the works of modern architects, is very humiliating to those who boast so loudly of progressive advancement in the arts and sciences; for there is scarcely a public edifice of recent date that will not be crumbled to dust, and blotted out of existence in a thousand years. Many splendid structures are mouldering monuments of folly in this respect. Stone intended for a durable edifice ought to be tested as to its resisting qualities and durability by immersion in a saturated solution of the sulphate of soda, and exposure to the air for some days. This process will cause crystallization within the stone and the same disintegration of its atoms that would result in time from the action of frost.

Crystalline, or granular limestone, will be found in considerable abundance, in large, irregular beds of many miles in extent, in the Laurentian formation. It would appear, from past explorations, to be mostly confined to large broken patches along its southern frontier. These patches may be found at variable distances, (northward) from the margin of the silurian rocks, to 50 or even 100 miles, but they are more abundant within the first 20 or 30 miles of the southern limits of the Laurentian formation. Its colors are white and clouded, of various shades. The finer variety resembles loaf sugar. It often contains scales of mica, and plumbago disseminated, and occasionally other foreign matter, from which the cloudings and shades of color arise. The finest and purest varieties of white crystalline limestones are used for statuary and the best carving, and are called *statuary marble*. A

variety less firm in texture is employed for building purposes, and makes a good material. They consist essentially of the carbonate of lime, or of the carbonate of lime and magnesia, and are the same in composition as the common flag-limestone of other formations, but are crystallized. They are easily scratched with a knife, and effervesce with acids. These rocks, when coarse, usually crumbles easily, and are not then a good material for building. But the best varieties are not exceeded in durability by any other architectural rock, not even by granite. For statuary it is essential that it should be uniform in tint, and without seams or fissures. The liability of finding cloudings within the large blocks makes them useless for statuary; and the presence of pyrites, or manganese unfits the stone for building purposes. The minerals generally associated with this rock are *tremolite, asbestus, scapolite, chondrodite, pyroxene, apatite, sphene, spinel, graphite, idocrase,* and *mica.*

Verd antique marble is a clouded green marble, consisting of a mixture of serpentine and limestone.

Serpentine is usually massive and compact in texture, and of a dark oil green, olive green, or blackish green color; also gray, white, and bright green, mixed or blended together; purer specimens of a rich oil green color, and translucent, breaking with a splintery fracture. It is rare in the Laurentian formation, but very abundant in the metamorphic rocks of Lower Canada, and is a beautiful stone when polished. Its composition is silica 42.3, magnesia 44.2, water 12.4, carbonic acid 0.9, and protoxyd of iron 0.2. *Precious* and common serpentine are easily distinguished from other green minerals by their dull resinous lustre and compact structure, in connection with their softness, being easily cut with a knife, and their low specific gravity. It commonly occurs as a distinct rock, and the varieties mentioned, as well as several others of little importance, but too numerous to mention in this place, either constitute the rock or occur in it. It is occasionally disseminated through granular or crystalline limestone, giving the latter a clouded green color: *this is the verde antique marble of the ancients.*

Meerchaum is a dull white earthy material like clay, light and soft, and is composed of silica 60.9, magnesia 27.8, water 11.3, oxyd of iron and alumina 0 1. When heated it gives out water and a feeted odor, and becomes hard and perfectly white. When first dug up it is soft, has a greasy feel and lathers like soap. It is used for making the bowls of Turkish pipes by a process like that for pottery ware. When imported into Germany, the bowls of the pipes are prepared for sale by softening them first in tallow, then in wax, and finally polishing them. Its probable occurrence amongst our Laurentian rocks has caused the introduction of the subject in this place.

Iron and its ores. *Native iron* is a mere curiosity, is very rare

and of no practical value. There is a fine Canadian specimen in the Geological Museum at Montreal.

Brown hemetote, brown oxyd of iron, brown ironstone, pipe ore, bog ore, is found of all shades of color, and under the most varying forms. Its streak and powder are always yellow, and the colour of the ore passing through all shades, from yellow to brown and black, and its lustre varies from the dulness of loam to the resnious brilliancy of pitch. Compact varieties are generally granulated, but are often found of fibrous texture and sickly lustre, passing from a lively brown to a jet black. This ore is so extensively distributed and appears under so many different forms that a description of it is very difficult. It is a hydrated oxyd of iron, and when pure is a peroxyd of iron containing about sixty per cent. of iron.

Red iron ore. Hematite, iron-glance, specular iron ore. The appearance of this ore varies from a dull brownish red to the lustre and color of polished steel or plumbago. Its powder is always red and its feel somewhat greasy. Some kinds of this ore possess the color and lustre of steel, others appears in crystals, in the form of fine leaves or cubes, and of the color and lustre of black lead.

The chemical composition of this ore, when pure, is oxygen 30, and iron 70, but it is frequently adulterated with clay or silicious matter, and is often found to contain but fifteen to twenty per cent. of metal, some kinds of red clay ore, though of an intensely red color, contain but five per cent. of iron. It is not attracted by the magnet, and if not too largely mixed with foreign matter, it forms one of the best and cheapest iron ores for the smelter. The quality of iron made from it is always found to be soft and strong, and particularly well adapted for the production of heavy wrought iron.

Magnetic iron ore occurs in large massive beds, and in the form of magnetic oxyd. or black sand, in our Laurentian rocks. This ore is generally bluish-black, and sometimes pitch black, with a metallic lustre, and accordingly hard. The compact and crystalline varieties are sometimes found in the same vein. Its powder and sand are exceedingly sensitive to the magnet. When it occurs in large pieces it is said to attract iron and to magnetize it when rubbed over it, but I think this is a mistake. The attraction of the iron is most likely caused by the small pieces of native magnet known to be imbedded in the ore. When this ore is in a pure state it is better adapted for making strong maleable iron than any other, provided it be not spoiled in the smelting process. This is the richest of the iron ores and, when pure, contains 70 per cent. of metallic iron in 100 parts. Some specimens contain only from 20 to 25 per cent. of metal; these are conglomerated, in which the crystals are imbedded in a cement of clay, silex, and often lime. Magnetic ore frequently contains foreign matter injurious

to iron, as silica, copper, arsenic, titanium, and sulphur; the latter often in large visible quantities, in the form of crystals of yellow pyrites.

Carbonate of iron constitutes the largest quantity of iron ore in the United States, but on account of its requiring a difficult and tedious treatment in preparing it for smelting—it is very little used. Some of the best iron in the Western States is manufactured from a decomposition of this ore. It occurs in the higher formations in the form of flattened spheroidal bodies, from the size of a pea, to a mass sufficient to weigh half a ton. These balls form either a continuous vein, in which one ball is laid beside and above the other, and the space between them filled with clay, or the balls are separated, sometimes many feet or yards, and imbedded in slate. Sometimes it is found in continuous veins, in a compact form, resembling limestone. It contains from 20 to 36 per cent. of iron. It has not, as yet, so far as the writer can recollect, been found in Canada, but may be found beneath some of the beds of hydrated oxyd, to which it becomes converted by the loss of its carbonic acid by exposure at the surface. Its composition is protoxyde of iron, carbonic acid, clay, silica, lime, and often magnesia, with, in most cases, in the centre of each decomposed ball, a black lump of manganese.

Sparry or *spathic ore* is a second variety of the carbonate of iron, which, in Europe, forms the first quality or quantity of the two species. In almost all instances when this ore occurs, it is more or less impregnated with sulphur, and in some cases with copper, which detracts seriously from its practical value. Its colour is generally white, varying to a yellowish brown, and dark brown. Its texture in the fresh fracture is always decidedly crystalline and of a silkey nature.

This ore frequently forms the main mass of a vein in which other valuable ores exist, and thus forms a guide to detect ores which would not otherwise be found. In North Carolina it forms the bulk of a vein of gold bearing ore, where it is accompanied by quartz, iron, and copper pyrites, and a large quantity of gold. It is associated with all kinds of metallic ores, changing the character of a vein from one kind of ore to that of another.

These constitute the great bulk of the iron ores proper. There are, however, some few ferruginous or iron bearing minerals, which are used in the manufacture of iron; but they do not constitute iron ores proper, and may be considered as fluxes. To this class belong ferruginous slate, shale, and clay slate, which contain iron, red marl, and green marl. These contain from five to ten per cent. of iron. Any mineral which does not contain twenty per cent. of iron is not considered an iron ore.

Iron pyrites.— As this mineral has been partially treated of before, we shall not have much to say in this place, but we deem

a further notice of it necessary. This ore is very properly not considered an iron ore; but it is a species of mineral of great importance and value, as will be seen by reference to former pages. There are two different kinds of common iron pyrites, [besides the arsenical and some other metallic pyrites) the one is yellow, of a brass or golden colour; the other is white, and of a silvery lustre. The chemical composition of both is nearly alike. One of them contains more than half its weight in sulphur, and the other part iron. These minerals are often confounded with more valuable substances, by those who are not expert metalurgists, on account of their great lustre, brilliancy of color, hardness, and general resemblance to gold. It is a very easy matter to distinguish it from gold or any other mineral, for the slightest heat drives off sulphurous acid, a most corrosive poison, having a suffocating smell which at once proves its character; besides, it is exceedingly hard, and will strike fire with steel, and fly in pieces under the hammer.

Sulphuret of iron is very extensively distributed in the rocky structure of the earth, and accompanies almost every description of mineral. It is found in all geological formations, as well as in alluvial soil and gravel. They are of little value in themselves, where not found in abundance. Where found in quantity, as before stated, they are of very great commercial value. It is, however, as the matrix of other metals, namely, as the bearers of gold, silver, nickel and cobalt, that they deserve more attention than they have hitherto received, and it is as such we intend to notice them in this place. All iron pyrites contain gold, and often silver, from which rule only those of the coal formation are excepted. The extensive gold deposits of the Southern States constitute a belt, or accumulation of veins of iron pyrites, which, when decomposed, liberate the gold, and it appears in a metalic state. The pyrites are the matrix of the gold. The veins of gold-bearing ore in those regions are, and have been, veins of pyrites, which are being decomposed at the surface, and to a certain depth beneath, as fast as the process of denudation takes place, when they yield up their gold to the alluvial washings: Below the point where the process of decomposition is reached, the veins are essentially formed of pyrites, and at a greater depth entirely so. The pyriteous slate of these regions contains gold in most cases where the pyrites are perfectly decomposed. It does not follow from this fact that all the sulphurets of this kind contain so much precious metal as to make them commercially valuable as an ore for the extraction of that mineral. It is not, therefore, at all improbable that the great abundance of pyrites which occur in the low subcrystalline, slaty rocks, of our Laurentian formation, may, on examination, prove to be gold-bearing, and be the matrix, from whence the large deposits now being found have been, and are being, liberated by the decomposition of these sulphurets of iron.

It may be asked,—How do you account for the existence of the precious metal in quartz veins? All fissures and veins in the rocky strata were occasioned either by the contraction of the solid matter, while passing from a state of fervent heat to that of coldness, or internal volcanic eruptions from beneath, and are therefore necessarily subsequent to, and of a much more recent date than the enclosing rocks that were rent asunder to form those fissures. These openings or fissures were filled with silica (quartz) held in solution in the waters that covered the land at that time, which was carried down into the fissures by those waters, or it might also just as readily be washed down in particles that had been previously liberated from the iron pyrites, by their decompo. sition into a sulphate or peroxyd when the country was dry land.

At first sight, and to the inexperienced, iron pyrites and copper pyrites are not easily distinguished from each other. Iron pyrites are, however, of a decidedly crystalline form, the other is not. The first are very hard, and will strike fire and scratch glass; the latter will do neither, and assumes all the colors of the rainbow, while the iron pyrites only ranges between silvery white (rare) and golden yellow to almost red. And now, while we are on the subject, we might, with advantage to many, lay down a simple process, whereby the presence of gold in pyrites may be easily determined. If iron pyrites are the matrix of gold, they must be opened to liberate and set the gold free. To test the presence of gold in a specimen of pyrites, it should be exposed to a gentle heat for three or four days, or it might, to greater advantage and saving of trouble, be placed in a clean open dish, and a little sulphuric acid applied to start the heat, which will, without further trouble, be kept up, while decomposition goes on, and the pyrites become changed into a soluble sulphate of iron, or the common copperas of commerce. The application of a little water will dissolve the sulphate, and the gold will be found in the bottom of the vessel. In this process, complete dissolution of the pyrites must take place, or the process must be repeated with the residue, or a new trial be made. Or, a specimen, say a couple of pounds, may be pulverized, or broken up finely under the hammer, and placed in an open, clean iron pan, to allow a liberal access of atmospheric air, and a gently raised heat applied. It will not take long to oxydize the mass, but care must be taken that the proto-sulphuret, which forms soon after the ore is exposed to heat, is not melted, and form clinkers. If it is, it will take a long time to oxydize the mass. The best plan in that case will be to pound the melted sulphuret, and roast it in an iron pot; or, if specimens are convenient, rather repeat the assay with more care. The roasting process is, however, a tedious one, as the roasting must be performed with particular care, for the particles of gold are very apt to en-

close themselves in particles of sulphuret, and thus escape detection. All the sulphuret should be converted into oxyd or ochre, or the gold cannot be separated from it. When oxydation is complete, the mass, rust, or ore, must be washed and treated with mercury like any other washings or gold-bearing ore; the manner of doing which has been already described.

Antimony is occasionally found native, but is usually combined with sulphur, or sulphur and lead, arsenic, oxygen, lime, nickel, silver, and copper. It rises easily in white fumes before the blow-pipe, without odor, and, in one or both of these particulars, is easily distinguished from other vaporizable metals. The ores fuse very easily, and all evaporate, some giving off fumes of sulphur. Specific gravity below 7.

Native Antimony is usually found massive, with a distinct lamilar structure. Color and streak tin-white; brittle. Hardness 3 to 3½. Gravity 6.6 to 6.75. Its composition is pure antimony, often with a little silver or iron. Fuses easily and passes off in white fumes. It occurs in veins of silver and other ores.

Sulphuret of Antimony passes through a great variety of forms, sometimes columnar, or fibrous, massive, granular, with a shining lustre, lead gray color and streak, liable to tarnish, lamina thin and brittle, but a little flexible; hardness 2; gravity 4.5 to 4.6. Its composition is antimony 73, sulphur 27. Fuses rapidly in the flame of a candle. On charcoal it becomes absorbed, giving off white fumes and a sulphur odor. It occurs in veins with ores of silver, lead, zinc or iron, and is often associated with heavy spar or quartz. This ore affords nearly all the antimony of commerce.

Besides the above there is an oxyd, which contains 84.3 per cent. of antimony, called white antimony. There are also over a dozen other combinations of antimony and other mineral bodies, the enumeration of which would carry us far beyond our limits.

Graphite–Plumbago is generally found foliated, massive, granular and compact. Its lustre is metalic; and color, iron-black to dark steel gray. The thin lamina is flexible. Hardness 1 to 2; gravity 2.09. Soils paper and feels greasy. It is infusible before the blow-pipe, both alone and with reagents, and is unaffected by acids. Its composition is 90 to 98 per cent. of carbon, with traces of iron. It is sometimes called a *carburet of iron*, but there is no chemical combination between the carbon and the iron—the iron is only accidentally present like any other foreign matter. This mineral resembles *molybdenite*, which is often mistaken for it; but while neither the blow-pipe nor the acids will effect the plumbago, the sulphide of molybdenum will gelatenize in the acid, and this will be a sufficient test to distinguish them, as well from one another, as from the other varieties of mineral which the more granular varieties resemble. This mineral is found in crystalline rocks, especially in gneiss, mica slate, and granular limestone, and

sometimes in granite, argellite, pyroxine, pyrallolite, quartzite, feldspatic rocks, and even magnetic oxyd of iron. It exists and is found in some abundance along the southern flank of the Laurentian formation, more particularly from the east side of the Ottawa to Gull Lake in the county of Victoria, and on examination may very probably be found accompanying the crystalline limestone of that formation to the Georgian Bay, and far into the interior. It is a valuable mineral when obtained in mercantile quantity and of sufficient purity, to be of commercial value; and, as it occurs pretty generally throughout our Canadian gold-fields, which are likely to be thoroughly examined very soon, the explorer who traverses that region in search of the precious metal is advised to keep a good look out for the occurrence of this mineral, as well as the one to be immediately described below, (which is of far greater value, and known to the writer to exist there,) and he may find something to his advantage, and of more value, than even the *precious* metal itself.

The principal English locality which hitherto furnished the pencil manufactories for centuries, was at Burrowdale in Cumberland, but the supply from that source becoming exhausted three years ago, it was finally closed. This mine was worked only for six weeks in each year, and during that short period realized $200,000 per annum on the sale of the material raised. It was not the state of purity, but the peculiar state of aggregation or combination in which its particles were held, that gave to the graphite from the Burrowdale mine its great value. It was ready for the saw when it came from the pit, and the sales were made monthly in London. The principal purchasers were the Jews, who were in the pencil manufacturing trade. The prices realized ranged from 35 to 45 shillings, sterling, per pound.

This mineral became so common a subject of robbery a century ago, as to have enriched many who lived in the neighborhood; a body of miners would break into the mine, and hold possession of it for a considerable time, till it was finally protected by a strong building, and the workmen required to put on a working dress in an apartment on going in, and take it off on coming out. In an inner room two men were seated at a table assorting and dressing the graphite. These men were locked in while at work, and watched by the steward from an adjoining room, who was armed with two loaded blunderbusses. These precautions attest the great value that was placed upon the mine, and was deemed necessary to check the stealing propensities of the Cumberland mountaineers. The granular graphite has been preferred for the manufacture of pencils, and it is this character of the Burrowdale graphite that rendered it so valuable.

According to a French mode, graphite of a coarse quality is ground up fine and calcined, and then mixed with the finest levi-

gated clay, (clay reduced to a fine powder,) and worked into a paste with great care. It is made darker or lighter and of different degrees of hardness, by varying the proportions of clay and the degree of calcination to which the mixture is subjected; and the hardness and color is also varied by the use of saline solutions and lampblack. Another method, in use in the United States, consists in finely pulverizing the graphite, and then, by a very heavy pressure obtained by machinery, condensed into thin sheets. These sheets are then sawed up to the required size, and the pencil is pure graphite. The foliated variety is preferred on account of its being freer from impurities. Our Canadian plumbago ought to be worth $100 per ton for ordinary polishing and other commercial purposes. There is a process adopted and patented in England for the conversion of loose pulverulent graphite into compact solid masses, in a state of absolute purity, for the manufacture of the finer quality of pencils, and it is said that our Canadian plumbago is admirably adapted for that process, a description of which would be too lengthy for these pages, but it consists of purification, exhaustion of the air, and consolidation by compression.

Molybdenum occurs in nature as a sulphuret, and sparingly as an oxyd; also, as molybdic acid in molybdate of lead. The *sulphuret* occurs in hexagonal crystals, plates, globules, or masses, thin, foliated, like graphite, and resembling that mineral. Its color and streak is pure lead gray, and slightly greenish. Laminæ thin and very flexible, but not elastic. Hardness 1 to 1.5; gravity 4.5 to 4.75. Its composition is molybdenum 59; sulphur 41 parts in 100. It is infusible before the blow-pipe, but when heated on charcoal sulphur fumes are given off, which are deposited on the coal. Dissolves in nitric acid, excepting a gray residue. This mineral resembles plumbago, but differs in its paler color and streak, and also in giving off fumes of sulphur when heated, as well as by its solubility in acid. It occurs in granite, gneiss, quartz, mica slate, and allied rocks; also in granular limestone, and has been found in the metamorphic rocks at the Harvey hill copper mine in the eastern townships, and in the Laurentian formation, at various places, in small quantities, from the Mingan Islands, in the Gulf of St. Lawrence, to the head of Lake Superior. With one exception it has not been found in commercial quantity in any place in that whole range, but the fact of its occurrence over such a vast extent of country is sufficient to warrant the belief, that it may hereafter be found, in many places, within that long range, in workable quantities. The writer has seen many places where considerable excavations were made by blasting in the crystalline limestone of the Laurentian formation, in the pursuit of pyrites, under the belief that they were gold, and at which places the mineral molybdenum was strewed around and rejected, under the belief that it was plumbago, and of no value. It is,

however, a valuable mineral, and is worth from $4 to $5 a pound, and well worthy the most earnest attention of explorers. It is known to the writer to occur in foliated globular masses in many places, from the size of a pea to that of a musket ball, imbedded in the quartz, crystalline limestone, and micaceous gneiss, of the Laurentian formation, and there can be but little doubt that it will be found in quantity in many parts of that formation when thoroughly examined. If the explorer will pay the slightest attention to what we have said on the subject of this and the preceding mineral (plumbago) he will have no difficulty in determining their characters, and less excuse for passing the more valuable by and rejecting it for the other.

Molybdic Ochre is an earthy yellow, or whitish oxyd of molybdenum, or rather molybdic acid, which occurs only as an incrustation.

Molybdate of Lead has a resinous lustre, and occurs in dull yellow octahedral crystals, (two four-sided pyramids placed base to base,) and also massive. It contains molybdic acid 34.25; protoxyd of lead 64.42.

It is only recently that the molybdicores became of any commercial value; they are now, however, of importance for the coloring matter contained in the acid. This coloring matter is of a very fine delicate blue tint, and is said to form and impart a beautiful and lasting color to silk in its manufacture. The price of molybdic acid in New York is about 75 cents per ounce.

Lithographic Stone is a compact grayish or yellow-grayish limestone, or magnesian limestone, of a very even texture, free from grit or foreign matter, having a conchoidal fracture, and used in lithography. At the base of the Trenton group of rocks, which immediately overlies the Laurentian formation, and along their line or junction, from Kingston to the mouth of the Severn River at the Georgian Bay, occurs a thin band of fine stone of the above description, which will be found exposed in many places; in some of which it is sufficiently fine-grained, and possesses the necessary fineness of texture to make good lithographic stone. These stones are exposed in the neighborhood of Madoc, Cobokonk, Rama, and many other places along the line of junction between the two formations before mentioned, as well as in many other parts of the Province; and it is somewhat surprising that our lithographers should be importing, and paying in New York 30 cents a pound, for a material that is no way superior to what occurs in Canada.

Zircon is usually found in crystals, but sometimes in square prisms, and octahedrons, (two four-sided pyramids placed base to base,) and granular. Its color is brownish-red, brown, and red, of clear tints; also yellow, gray and white. Its streak is uncolored, and its lustre more or less adamantine, and often transparent, but occasionally opaque, with a brilliant conchoidal fracture. Hard-

ness 7.5; gravity 4 to 4.8. Consists of silica 33.2; zirconia 66.8. Transparent red specimens are called *hyacinth*. A variety from Ceylon is sold for inferior diamonds, which it much resembles, though much less hard. The hyacinth is readily distinguished from spinal by its prismatic form and specific gravity, as well as its adamantine lustre, and a less clear shade of red. Its infusibility, hardness, and other characters, distinguish it from tourmaline, idocrase, staurotide, and the minerals it resembles. Zircon is confined to the crystalline rocks, including lavas and crystalline limestone. The clear crystals are of common use in jewelry. When heated in a crucible with lime they lose their color, and resemble a pale straw-yellow diamond, for which they are substituted. It occurs in the Laurentian formation, and some very fine specimens, said to constitute veritable gems, have been found therein by some of the members of the geological survey.

Pink Garnets occur in some abundance in many places in the Laurentian formation. They occur white, brown, black, and green, but the deep red color is prevalent. They are brittle, and transparent to opaque, with a vitreous lustre. They are composed of the silicates of alumina, lime, iron, and manganese, and the varieties of color arise from their various combinations. Oxyd of chrome is sometimes present, producing an emerald green variety. Precious garnet is a clear deep red variety, much used in jewelry, and makes a rich gem. Those of Pegu are most highly valued, and are cut quite thin on account of their depth of color. An octagonal garnet, measuring 8½ lines by 6½, (about half an inch in diameter,) has sold for $700. They occur abundantly in mica slate, hornblende slate, and gneiss, and somewhat less frequently in granite quartz and granular limestone; sometimes in serpentine and lava. The vitreous lustre of their fracture, without a prismatic (4 or 6 sided) structure, even in traces, and its usual dodecahedral forms, (12 rhombic faces) are easy forms for distinguishing it. Tourmaline has less specific gravity; staurotide differs in being infusible; and idocrase fuses much more easily. Garnets and garnetiferous sands are pretty abundant about Trading lake, Hollow lake, and Vernon lake, and further to the north, and to the east and west of those places.

Tourmaline is usually found in prisms, terminating in a low pyramid. They are commonly long, and often have only three prismatic sides, which are convex and strongly furrowed. It occurs also compact, massive, and coarse columnar, the columns sometimes radiating or divergent from a centre. Color, black, blue-black, and dark brown, common; also, bright and pale-red, grass-green, cinnamon-brown, yellow, gray, and white; sometimes red within, and green externally, or one color at one extremity another at the other. Transparent; usually translucent to opaque. Lustre, vitreous, inclining to resinous on a surface of

fracture; streak uncolored. Brittle: the crystals often fracture across and break very easily. Hardness 7.8; gravity 3 to 3.1. Electrically polar when heated. There are a great many different varieties of this mineral, which differ very much in composition. Before the blow-pipe the dark varieties intumesce, (or froth,) and fuse with difficulty, while the red and light-green only become milk-white and a little slaggy on the surface. They are essentially composed of silica, alumina, lime, protoxyd of iron, soda, &c., varying with the colors, or rather the colors varying with the composition. The red, green, and yellow varieties are distinguished from any other species they resemble by the crystalline form, the prism of tourmaline always having 3, 6, 9, or 12 prismatic sides, or some simple multiple of 3. The electric polarity of the crystals when heated, is another remarkable character of this mineral. Tourmalines are common in granite, gneiss, mica slate, chlorite slate, steatite, and granular limestones. They usually occur penetrating the gangue. The red crystals, when transparent and free from cracks, are of great value, and afford gems of remarkable beauty. They have all the richness and lustre belonging to the ruby, though measuring an inch across. A Siberian specimen of this variety, now in the British Museum, is valued at £500 sterling. The yellow tourmaline, from Ceylon, is but little inferior to the real topaz, and is often sold for that gem. The green specimens, when clear and fine, are also valuable for gems. A stone measuring 6 lines by 4, ($\frac{1}{2}$ by $\frac{1}{3}$ inch) of a deep green color, is valued at Paris at $15 to $20. These more precious minerals, of which we have been speaking, occur in our Laurentian rocks, and while the explorer is in the field in search of others, are worthy of his careful attention and close observation.

Ochre, both red and yellow, is an impure hydratted oxyd of iron, and arises from the decomposition of iron ores. This is sometimes effected by the influence of the oxygen of the atmosphere on the iron ore, but more generally by the water permeating the strata, carrying down with it some vegetable acid from decayed vegetable matter, and coming in contact with subterraneous deposits of iron; the acid attacks the iron, dissolving and setting it free, to be held in solution in the water, and floated off to some other and less elevated locality, where it appears on the surface, and the oxygen of the atmosphere attacking the iron thus held in solution, precipitates it in the form of a brown or yellow hydrated oxyd. Yellow ochre, when burnt, becomes more highly oxydized, and assumes a red color. It is then ground and prepared for use, and forms red ochre, and spanish brown. There are large and valuable deposits of this mineral in Lower Canada, as well as many smaller ones in Upper Canada, which might be wrought to advantage.

Sulphate of Baryta, or Heavy spar. Trimetric, in modified rhombic and rectangular prisms, with crystals usually tabular;

the massive varieties are often coarse lamellar; also columnar, fibrous, granular and compact. Lustre vitreous: color white and sometimes tinged yellow, red, blue, or brown. Transparent or translucent. Hardness 2½ to 3½. Gravity 4.3 to 4.8. It is composed of Baryta 66, and sulphuric acid 34. It is often the gangue, or matrix, of the ores of metals. Heavy spar is ground up and used as white paint, and in adulterating white *lead*, and for that purpose is worth, in the Boston market, about $40 per ton. It occurs in some abundance in the Huronian formation, at Lake Superior, and also in the Laurentian formation. *Carbonate of baryta* is another variety which contains carbonic acid, instead of sulphuric acid. It contains baryta 77.6, carbonic acid 22.4. This mineral is poisonous and is used in the North of England for killing rats. The salts of baryta, which are much used in chemical analysis, are made from this species; the nitrate produces a yellow light in pyrotechny, and the prepared carbonate is a common water color.

Calc spar or carbonate of lime is important as a vein stone, in which are often found many valuable minerals. It apparently assumes a great variety of crystalline shapes and forms, and sometimes occurs fibrous with a silky lustre, sometimes lamellar, and often coarse or fine granular and compact. The purest crystals are transparent with a vitreous or glass-like lustre; the impure varieties are often opaque and earthy. Different names have been applied to the more prominent varieties. The colours of the crystals are either white, or some light grayish, reddish, or yellowish tint, rarely deep red; occasionally topaz yellow, rose or violet. The massive varieties are of various shades, from white to black. Hardness 3, gravity 2.5 to 2.8. Its composition is, lime 56, carbonic acid 44. Infusible before the blowpipe, but gives out an intense light, and is ultimately reduced to quick lime. It effervesces with acids, and is easily scratched with a knife; which characteristics, with their complete infusibility, will readily distinguish them from other vein stones. Their occurrence in the Laurentian formation, which is in so many places, destitute of limestone for the manufacture of lime, is of the highest importance; for, apart from their being valuable as the probable matrix of other mineral bodies, they will, when burnt, form quick lime, and this cannot but be a matter of considerable moment in the future settlement of that vast region. (Do not, however, make a mistake and endeavor to *burn quartz rock into quick lime*, as was the case at Trading lake, not long ago, when the writer happened to be passing). It is easily burnt, as the heat drives off the carbonic acid, and leaves the lime in a pure or caustic state. Some of them, as well as other lime-bearing rocks, which contain clay disseminated through them, often burn into *hydraulic lime*, a kind of lime, of which a cement or plaster is made, that "sets" under water.

Platinum, Iridium, Osmium, Rhodium, and Palladium are called platinum, or the precious metals, because they always appear together, or alloyed, and generally accompany gold, but rarely in such quantities as to be of any importance. They are, nevertheless, as valuable as gold, and some of them sell at even higher prices than that metal. They are chiefly found in gold regions where the gold occurs, and mostly or exclusively in alluvial ground and sand. Platinum appears in flattened grains, of a grayish lead color, resembling tarnished steel, and in its ordinary state is as heavy as gold, and can be obtained, if present, in the wash pan along with the gold. Their possible occurrence in the Canadian gold region, and particularly in the bottom of the pan, along with gold, should not be overlooked by the miner or explorer. They are easily separated by a chemical process, and obtained in a state of purity; but, a description of which would be too lengthy in this place, particularly in view of the unestablished fact of their existence in our Upper Canada gold fields, of which, and its mineral resources this work is almost exclusively designed to treat.

Chromic iron is the only ore of practical use of the mineral *chromium*. It occurs in some abundance in many parts of the newer and more recent metamorphic rocks of Eastern Canada, in association with serpentine. The color of this ore is brownish-black, resembling black manganese, but it is harder and almost of metallic lustre. Its powder is brown, and the mass is brittle. The best qualities of this ore produces 60 per cent. of the oxyd of chromium. The remainder is iron, clay, and siliceous matter. The chrome used in the arts is always obtained from this ore, and is the compound of chromic acid with potash, from which are prepared both the red and yellow chromates of lead. The green oxyd of chromium is also prepared from the salt, and is used as an indelible green color in painting, and for the preparation of an indestructible green printing ink. Large quantities of the bichromate of potash are used in dying and in calico printing, and it is said that, South Lancashire, alone, in 1861, manufactured fourteen tons per week. The chromic iron ores of Canada are rich in acid, and are worth one dollar currency, per ton, for each unit of chromic acid they will produce. Thus the ore from Bolton, Canada East, which gave by analysis 45.9 per cent of oxyd of chromium, would yield 60 per cent. of chromic acid, and be worth $60 per ton, in its raw state, delivered in England, where, in the place above mentioned, alone, the consumption must be equal to 1000 tons of ore, yielding 50 per cent. of chromic acid. The principal supplies of this ore are now obtained from Pennsylvania and Maryland, and from Norway. The process of manufacturing the bicromate of potash is one which might, to great advantage, be carried on in this country. It consists simply in calcining (or roasting) the finely ground ore, with crude potash, in a proper furnace, exposed to a current of

air, by which the chromic oxyd becomes acidified, and unites with the potash. The resulting mass is next lixiviated, or leached, with water, and the solution, being mixed with a certain amount of sulphuric acid, furnishes, by evaporation, crystalline bicromate of potash. In the absence of sulphuric acid a crude neutral chromate might be prepared by simple evaporation and shipped to England to be there converted into bichromate. The cheapness and facility with which the ore, the potash, and the requisite fuel may be obtained, in the neighborhood of those deposits, combined with its ready means of transportation, are such as to offer great inducements for the working of the chrome ores of this country.

Nickel. The ores of nickel, excepting one or two, have a metallic lustre and pale color. Their specific gravity is between 3 and 8, and hardness between 5 and 6. They resemble some cobalt ores, but do not, like them, give a deep blue color with borax. There are several varieties of ore, or combinations of ores, containing nickel, such as arsenical, antimonial nickel, nickel pyrites, emerald nickel, &c. &c., a description of each of which would be very lenghty and out of place here. It has been found in the Eastern Townships; near Brockville; and at Lakes Huron, and Superior, generally associated with cobalt. These ores are generally very poor, but the high price of nickel in the market will allow very poor ores to be wrought to advantage. It is found in iron pyrites, in calcspar, serpentine, gneiss, chrome iron, and generally accompanies cobalt, silver and copper ores.

Cobalt ores generally have a metallic lustre, tin white, or pale steel gray, inclining to copper-red color, and a specific gravity from 6.2 to 7.2. The ores of cobalt are remarkable for giving a deep blue color to glass of borax before the blowpipe, even when the proportions of cobalt are so very small. The ores having no metallic lustre have a clear red, or reddish color, and specific gravity of nearly 3. *Tin-white cobalt* consists of cobalt in combination with arsenic which varies from 18 to 24 per cent. of the former, and 69 to 79 of the latter. It occurs in octahedrons, (4 sided prisms, placed base to base), cubes, dodecahedrons, (four sided pyramids placed base to base, twelve faces) reticulated and massive, and gives off arsenical fumes in a candle flame; colors borax, and other fluxes, blue, and affords a pink colored solution with nitric acid. It is usually found in veins with ores of silver and copper.

Black oxyd of cobalt is a black, or blue-black, earthy mineral, soluable in nitric acid, with fumes of chlorine. It occurs in an earthy state mixed with oxyd of manganese, and is sometimes mistaken for the black oxyd of copper. Nickel and the sulphuret of cobalt occasionally occurs with the oxyd. This ore is exported to England in large quantities and there purified and made into *smalt* for the arts.

Arsenate of cobalt is another ore of arsenic and cobalt, which occurs in oblique crystals having a highly perfect cleavage and foliated structure like mica. It also occurs as an incrustation, and in reniform shapes, sometimes stellate—star-like. Its color is peach and crimson red, and lustre of the laminæ pearly. The earthy varieties have no lustre. It is transparent to subtransparent. Hardness 1.5 to 2, gravity 2.95, composition: oxyd of cobalt 37.6, water 24.0 parts in one hundred. Gives off arsenical fumes when heated, and fuses, and yields a blue glass with borax. It is found with ores of lead and silver. Cobalt is most always associated with nickel, and the two ores are generally found together. It has been, found in many places, in both Provinces, but the only place, so far as known, where it occurs in available quantities is in an extensive deposit of iron pyrites, at Elizabethtown, near Brockville. These pyrites have produced, on analysis, eight pounds of cobalt to the ton, which, at $3 per pound, gives a yield of $24 per ton; and this calculation is based upon only two-thirds of the actual yield, while the expense of extraction and marketing was estimated at $14.00 per ton, and the whole of the other available and valuable materials, including the sulphur and nickel, rejected. It would be well for explorers, on finding deposits of pyrites, to have them carefully tested, not only for gold, but also for cobalt and nickel, the latter being worth over $1 per pound.

Manganese ores have a specific gravity below 5.2, and afford a violet-blue color with borax, or salt of phosphorus, in the outer flame of a blowpipe; and on heating the oxyd with hydrochloric acid, fumes of chlorine are given off, which are divided from the acid.

There are only two or three principal ores of this metal which are of practical value; the others are merely objects of science. The most abundant ore is the *Black peroxyd*, which consists of 63 per cent of metal, and 36 of oxygen. It is a very dark brown mineral, and, generally, has a velvety appearance, when it has been exposed to the atmosphere. In the fresh fracture it is close, compact, and of a vitreous lustre. Another variety is composed of the oxyd of manganese 52.6, silica 39.6, oxyd of iron 4.6, lime and manganese 1.5, water 2.7. Its colour is generally a deep flesh red, also brownish, greenish, or yellowish when impure. It occurs usually in large massive rhombic prisms; lustre vitreous; transparent to opaque; becomes black on exposure; hardness 5.5 to 6.5; gravity 3.4 to 3.7. Resembles somewhat a flesh red feldspar, but differs in greater specific gravity, and blackening in the glass with borax.

Bog manganese consists of peroxyd of manganese in varying proportions from 30 to 70 per cent., along with peroxyd of iron, and 20 to 25 per cent. of water, and often several per cent. of oxyd of cobalt and copper. It is a hydrated peroxyd mechanically mixed

with other oxyds, organic acids, and other impurities, and, like bog iron ore, is formed in low places, from the decomposition of minerals containing manganese. It gives off much water when heated, and affords a violet glass with borax. It is found in every geological formation, in or near the oldest rocky strata, in volcanic regions, and in alluvial gravels. It is used in glass works to impart a violet blue, the manufacturing of chlorine for bleaching, the production of oxygen, in calico printing, and may be used for umber-paint. This latter specimen is found in some quantity in many parts of Lower Canada, and at Bachawaning Bay, at Lake Superior, and may yet be found in commercial quantity in our Upper Canadian Laurentian rocks.

Zinc occurs in combination with sulphur, oxygen, silica, carbonic acid, sulphuric acid and alumina. *Blende* is the sulphuret of zinc, and is composed of 68 per cent. of zinc and 32 per cent. of sulphur. This ore is always found crystalized; and, in most cases, the masses of it are mere accumulations of crystals. Its color is generally a bright or reddish brown, but it is sometimes black, red, green or yellow. It is transparent, or at least admits of the passage of light if in thin splinters. The lustre of this ore is brilliant and more decidedly adamantine than any other ore. It is found in heavy veins and masses in the gold regions of the Southern States, where it forms the principal silver ore. It also contains gold, and is associated with galena, iron and copper pyrites, tin, heavy spar, black manganese, and manganese spar, but is chiefly worked for its silver and gold. It occurs in rocks of all ages, and is associated generally with ores of lead, copper, iron, tin and silver. This ore is the "Black Jack" of the mines. It is useful as an ore of zinc, though difficult of reduction. *Red zinc ore* is a compound of oxyd of zinc, manganese, and oxyd of irons. Its color is brick-red, with a yellowish tint like cinnabar. Its texture is granular and massive.

Silicate of zinc occurs in modified rhombic prisms; also, massive and encrusting, mammilated or stelactitic; color white, sometimes bluish, greenish, or brownish; streak uncolored. Transparent to translucent: lustre vitreous or subpearly, brittle; hardness 4½ to 5; gravity 3.85 to 3.49; pyro-electric.

Apart from the above, there are other varieties of zinc ore, of no great importance in a commercial point of view, the enumeration of which would be of no practical utility in this place.

Titanic iron, in crystallization, has much the appearance of specular iron. It is often found in thin plates, or quartz seams; also in smalt grains in black sand. Color iron-black; streak and lustre metallic; hardness 5 to 6; gravity 4½ to 5. It is an oxyd of iron, holding a variable proportion of titanic acid or oxyd of titanium. There are a number of species of this ore with as many different

names. It occurs in quantity at Bay St. Paul, below Quebec, where it has been opened, and some of the ore introduced into the market. This ore, which is generally very free from any earthy admixture, contains 48 6 per cent. of titanic acid. This is also sometimes found in orange-red crystalline grains, disseminated through the ore, thus increasing its richness in titanium. This mineral has hitherto received little attention, and but few applications in the arts; and, until a very recent date—during which large deposits of titanic iron ore have been found in the Laurentian formations of Canada, and Norway—it was comparatively a rare substance. It is, however, just now receiving considerable attention in the scientific world, and from the advance already made, in the endeavor to convert the acid to some useful purposes in the arts, there is little doubt that it will, ere long, receive as extensive an application, and be converted to as many useful and important, though different purposes, in the commercial world, as the acid which is extracted from its sister ore—chrome iron. In which case the Laurentian rocks of Canada will be able, probably, to supply it in inexhaustible quantities.

Sulphur. There are no mineral deposits of pure sulphur found in Canada; at least, not in sufficient quantity to be of practical use; but there are great deposits of metallic and other sulphurets, from which the mineral might be profitably extracted. Sulphur may be obtained from iron pyrites, by simple distillation in iron or stone retorts, when they will yield about one-half the sulphur they contain. The residue can be easily converted into sulphuric acid, or copperas. In this process the pyrites can be very readily made to yield up, with comparatively trifling additional expense, any of the more precious minerals, gold, nickel, or cobalt, they may contain; and this fact should not be lost sight of by capitalists, or those who may contemplate embarking in the manufacture of sulphuric acid from the pyriteous deposits of Canada.

Peat is a material found in lowgrounds and swamps, and if sufficiently pure, forms a fuel of considerable value. It is an accumulation of decayed or carbonized plants, grasses, &c., which grow and sink on the spot where it is found. It is purest where deep, free from disturbing causes, or freshets, or streams, whereby sedementary clays and sands are washed down and deposited along with the vegetable matter. There are vast and almost inexhaustible deposits of peat in Canada. This wise provision of Providence will, in a great measure, compensate us for the complete and irremediable absence of coal from our Canadian strata; and will, as our forests disappear before the bushman's axe, be generally introduced and succeed the "cordwood" now so expensive along and in the frontier and larger cities of Canada. Where wood and coal can be obtained at a reasonable price, peat cannot be introduced to succeseful and remunerative competition. But when the market value

of these indispensable necessaries of civilized life, has ruled so high as to have reached and maintained the famine prices of the last few years, successful competition need not be feared; and we are glad to learn that several enterprising companies, foreseeing the necessity, and the pecuniary advantage to be derived therefrom, have purchased extensive tracts of peat land and commenced active operations, with the view of supplying the market with fuel at a cheaper rate. We wish them every success.

Peat is said to be peculiarly adapted for the smelting of iron ore, and the heating and hardening of steel, and for this purpose the turf is pressed and charred, the fire of the raw wet material being found injurious. As Canada is one of the richest iron-containing countries in the world, and as it possesses the necessary fuel for its manufacture, in great abundance, who can foretel the limit to which she may not attain in the future, in the manufacture and exportation of that one article of commerce, as well as that of many others of her vast resources? It is to be hoped that the day is not far distant when her people will shake off their apparent apathy, arouse themselves to the fact that she is great and rich in all that can conduce to material prosperity, and make a nation great and wealthy, and her people prosperous and happy. Why not make use of the wealth that stares them in the face, thereby reversing the tables, and making her a manufacturing and exporting country, instead of an impoverished, consuming, and importing Province?

Diamonds are pure carbon, and have been found in almost all the gold regions of the world. Where gold, and particularly coarse gold, is found in alluvial soil, there is a probability of the presence of diamonds. The geological formations in which gold is found, generally speaking, possess strong indications of their presence; but they are always found at a much greater distance from the surface of a gravel bed than gold. The matrix of this mineral appears to be that gravel of the gold formations known by the name of "pudding stone," in which quartz pebbles are cemented together by the oxyd of iron. If diamonds are present in the wash-pan they can readily be detected by their great brilliancy and sparkle, if the washing is performed in the bright sunlight.

Tin ore generally occurs in granite, in heavy masses or lodes, mixed with conglomerates of various rocks. It is also found in alluvial gravel as the result of the decomposition of the above rock, and is then called stream tin. It has a variety of colors, white, gray, yellow, red, brown, and black; but its most striking feature is its weight, which is about equal to that of galena, from which, however, its hardness, brilliancy of lustre in the fresh fracture, striking fire with steel, and frequent double detached crystallization, readily distinguish it. *Tin pyrites* are not very abundant, and the extraction of tin from them is not profitable. This ore is

of a gray or yellowish color, heavy, crystallized, and of a metallic lustre, and is always found to be adulterated with foreign matter, as iron, copper, lead, and other ores, which predominate so much as to make the smelting of tin from them impracticable, or so difficult and expensive, as to render it unprofitable.

Native Copper is found in large quantities in regular veins in the State of Wisconsin, near Lake Superior, and is in small quantity, or of rare occurrence, on the Canada side of that lake. These masses of copper are imbedded in volcanic rock, and small veins ramify it in all directions. It occurs in bodies of almost every size, from mere grains to enormous masses, weighing many tons. It is occasionally found to be mixed with silver in distinct fibres, and unalloyed with the copper. It dissolves in nitric acid, and produces a blue solution with ammonia. Native copper has not as yet been found in any quantity in Canada, but as there are numerous indications of its existence in many places from one extreme of the country to the other, it is not improbable that it may yet be found to exist in paying quantities in more than one locality.

Sulphuret of Copper, or vitreous copper ore, is the ore from which most of the copper of commerce is smelted, and it is pretty generally distributed in the metamorphic and crystalline rocks of the earth's surface. There are two kinds of ore of this variety; the one is called gray sulphuret of copper, and the other copper pyrites; this latter generally contains iron in combination with the copper and sulphur. The vitreous sulphuret contains copper 77.2; sulphur 20.6; iron 1.5; and gives off fumes of sulphur before the blow-pipe. It fuses easily in the outer flame of the blow-pipe, and after the sulphur is driven off a globule of copper remains. It dissolves in nitric acid with the precipitation of sulphur. The vitreous copper ore resembles vitreous silver ore, but the lustre of the fracture is less brilliant, and they give entirely different results before the blow-pipe. The easiest and most ready way of determining whether it is a silver or copper ore would be by putting the blade of a knife in a diluted solution of the ore, after it has been dissolved in nitric acid; if it is copper it will coat the blade with copper; if the ore contains silver, it will coat a plate or piece of clean copper with silver. In both cases a small portion of the solution must be mixed with three or four times the quantity of water, or the acid will attack both the blade of the knife and the copper. This ore occurs in some abundance on the north shores of lakes Huron and Superior, in the eastern townships, and is found in the Laurentian rocks of Upper Canada, to the north of Belleville, Kingston, and Balsam Lake.

Copper Pyrites, or sulphuret of copper and iron, resemble iron pyrites, but may be easily distinguished from the latter by their irridescence or bright rainbow colors. This ore is always accompanied by iron pyrites, the latter often decidedly predominating.

Its composition is sulphur 34.9; copper 34.6; iron 30.5. It fuses to a magnetic globule before the blow-pipe, and gives off sulphur fumes on charcoal, and with borax affords pure copper. It gives a similar effect as the vitreous copper ore with nitric acid. This ore resembles native gold, and also iron pyrites, but can be easily distinguished from gold, by crumbling when attempted to be cut instead of separating in slices; and from iron pyrites in its deep yellow color, and in yielding easily to the point of a knife. This ore occurs in granite and its allied metamorphic rocks, and is usually associated with iron pyrites, and often with galena, (lead) blende, (zinc) and carbonates of copper. It is a very common ore, and is sometimes found in serpentine in gneiss rocks. It varies in yield from 2 to 40 per cent. of metal. This ore generally accompanies gold-bearing pyrites, and may be considered a good indication of richness. Considering the extensive distribution of this ore, its great utility to smelting works, and its general demand in the neighboring republic, it is to be regretted that it is not more extensively mined in a country that could afford it so abundantly as Canada. The smelting works of the atlantic cities pay $3.00 (gold) for each per cent. of copper in the ore: now, a ton of ore, which contains 10 per cent. of copper, would bring $30, and as ore containing this and a much larger proportion of metal is plenty in Canada, and railroad and shipping facilities are all that could be required, it certainly ought to be a good, profitable business to embark in the development and shipment of copper ores.

In Germany, copper ores which, in most instances, contain only one per cent. of copper and a little silver, are extracted and smelted to advantage; it cannot be considered difficult or unprofitable here in Canada, where the veins are frequently found to be heavy, to work to good advantage mines which furnish ores containing five to ten per cent., and often much more copper, not saying anything of the sulphur and other valuable metals that usually accompany such ores.

These ores are the most generally distributed; still, we often find others, but their quantity is comparatively small. They are the *Red Oxyd*, of a lively red color; the *Black Oxyd*, of a violet black color; the *Silicious Oxyd*, of a green color; the *Carbonate*, of a blue color; the *Phosphates* and the *Chlorides*, both of a green color; but these, with a great variety of others, are better fitted to occupy a place in a cabinet of curiosities, than any useful purpose in this treatise, or to the practical explorer, only so far as they serve as an indication, where found, of the presence of the first three mentioned above. The richness or value of the copper pyrites may be generally judged from their color; if of a fine yellow hue, and yields readily to the hammer, it is a good ore; but if hard and pale yellow, it contains largely of iron pyrites, and is of poor quality.

Lead is seldom found in a pure state. It is generally in combination with sulphur and various acids; when found it is of no practical value whatever, because it only occurs in very small quantities, and it costs but little to smelt it from its ores. The most important lead-bearing ore is *galena*, or the sulphuret of lead. It occurs in perfect cubes, and of a bright metallic lustre. Its hardness is 2.5; and gravity 7.5 to 7.7; and when pure contains 86½ per cent. of lead, and 13½ per cent. of sulphur. It often contains some sulphuret of silver, and is then called *argentiferous galena*, and sometimes sulphuret of zinc is present. This ore resembles some silver and copper ores in color, but its cubical cleavage, or granular structure when massive, will usually distinguish it. Its powder, however, when finely rubbed, is black, and the ore is very heavy. It is found in granite, limestone, clay-sandstone, and almost all through the whole geological range of rocky strata, except the bituminous coal regions, and is often associated with ores of zinc, silver, and copper. *Quartz, baryta*, (heavy spar) *calcspar, or carbonate of lime*, is generally the matrix, or gangue, in which galena is found; but it sometimes occurs in fluorspar, and often large deposits are found in *mountain* or *magnesian* limestone. Some varieties of galena contain a high percentage of silver; but, when this occurs, the ore is generally mixed with other minerals. The Missouri galena does not contain sufficient silver to pay for separating it from the ore, while the Arkansas galena is so rich, in silver, that they send it to England to be smelted. Galena containing silver has been found in many parts of Canada, but it is not so generally known, or appreciated, as it deserves to be. The proverbial apathy and indifference of Canadians to the great mineral wealth of their country, and perhaps, the difficulty of smelting this ore to advantage, may be in the way of its more general application, and better state of development here; but I am inclined to the opinion that it is the former.

Red oxyd of lead is a heavy pulverulent, bright red and yellowish mineral, much like red chalk, but will let fall globules of lead in the reduction flame of the blowpipe, and is commonly associated with galena. This is the red lead of commerce; but can be, and is, extensively prepared artificially. Lead is calcined (roasted) in a reverberatory furnace, and a yellow oxyd is thus formed, which is afterwards heated in the same furnace in iron trays, at a low temperature, by which the lead absorbs more oxygen and becomes red lead. A much better material can, however, be obtained by the slow calcination of white lead. This mineral (red oxyd of lead) was found, by the writer, close to the Pinnacle mountain, near Danville, in the Eastern Townships.

Sulphate of lead occurs in the form of right rhombic prisms, in crystals, massive, lamellar, or granular, having a white, or slightly gray or green color, and adamantine lustre, which sometimes in-

clines to resinous or vitreous. It is transparent to nearly opaque, and is soft, having a hardness of only 2½ to 3, and the heavy specific gravity of 6½. It contains 73 per cent. of the oxyd of lead, and fuses before the blowpipe to a slag, yielding a globule of lead with carbonate of soda. It does not effervesce in nitric acid, and is usually found associated with galena, and results from its decomposition.

Carbonate of lead is an ore of frequent occurrence, and is found in modified right rhombic prisms, often in compound crystals, either in six sided prisms, or in wheel shaped groups, of four or six rays, and also massive and pulverulent as a compact white powder. It contains 83½ per cent. of the oxyd of lead, and 16½ per cent. of carbonic acid, passes through various shades of color, from white to dark, fuses, and, with care, affords a globule of lead, and effervesces in dilute nitric acid. This is the white lead of commerce, so extensively used as a paint. But the material for this purpose is abundantly made and prepared by artificial means, the process of which would be too lenghty and complex for insertion here. It more particularly belongs to the chemical manufacturer, and therefore can be of little interest to the explorer.

Phosphate of lead occurs in the form of six sided prisms, in globules and kidney-shaped masses, with a radiated structure. Its color is bright green, or brown; sometimes fine orange-yellow, owing to the presence of chromate of lead. Its streak is white, or nearly so, and its lustre more or less resinous, and partially transparent. Hardness 3½ to 4; gravity 6½ to 7. Its composition, oxyd of lead 78; muriatic acid 1.65; phosphoric acid 19.73. It fuses before the blowpipe on charcoal, and on cooling the globule becomes angular. This mineral has some resemblance to beryl and apatite, (a six sided crystal of phosphate of lime), but it is much heavier, and quite different in its action before the blowpipe.

Chromate of lead occurs in oblique rhombic prisms, massive, of a bright red color, and translucent, and has a streak of orange-yellow. It is composed of chromic acid 31.85, protoxyd of lead 68. 15. It produces a yellow solution in nitric acid, and blackens and fuses before the blowpipe, and forms a shining slag containing globules of lead. It occurs in gneiss, and is the chrome-yellow of the painters. It is, however, made in the arts by adding to the chromate of potash in solution, a solution of the acitate or nitrate of lead. The chromate of potash is usually procured by means of the chromic iron ore—which see.

There are, besides the above, quite a variety of minerals which contain lead, but they are of little interest or value as ores. The galena found in limestone formations, or accompanied by lime, is generally very poor in silver. The largest and most numerous beds of lead ore are found in and near limestone rocks. The lead ores of *siliceous* formations, particularly those found in slates, are

generally rich in precious metal; and it may be said that the lead ores of the oldest rocks are the richest. From the many indications of the occurrence of lead ores in many parts of the country, both in the the Upper and Lower Provinces, there can be little doubt but that there is more lead in the country than we are aware of, and it may yet be found in still larger quantities than heretofore. However, the price of lead is so low in the market, that the raising of lead ores cannot be considered a profitable business, unless the body of the ore is very large, and can be raised, and transported cheaply. Still, lead ore may be very profitable, if the quantity of silver in it is sufficient to pay for extraction, smelting, and refining, and, as we have before stated, the richest silver-bearing lead ores being confined to the older rocks; we should not let that fact escape our attention in our explorations in search for gold, through the old metamorphic rocks of the Laurentian formation, where, if not found in quantities as a lead ore, it is very likely to be rich in silver, and therefore of far more intrinsic value, though small in quantity.

Silver occurs native and alloyed; also mineralized with sulphur, selenium, (transparent-foliated gypsum) arsenic, chlorine, bromine, or iodine, and in combination with different acids. Silver ores fuse easily, and decompose before the blowpipe, giving a globule of silver, either alone, or with soda. The globule is known to be of silver by its flattening out easily under a hammer, and also by its sectility. The different species of silver ores, varies in specific gravity (or weight, as composed with water) from 5½ to 10½. That is, from 5½ to 10½ times heavier than an equal bulk of water. *Native silver* is found in various shapes and forms, and it is often difficult to decide by sight, whether a mineral is pure or contains silver in admixture. It is found in all mines where silver ores occur, in the regular form of crystals, but principally in irregular grains and formless aggregations. It appears in the native copper of Lake Superior, ramifying the copper in all directions in the form of fine threads of pure silver. Silver has a great affinity for sulphur, which soon blackens its bright surface, and for this reason most of the native silver is found imbedded in black masses in the silver ores, filling fissures in a vein, or appearing as a black vegitatation in cavities, or on the surface of a vein. Most of the silver in the United States is derived from gold. All the gold brought to the mint from the mines contains some silver, varying in amount from one to fifteen per cent. and upwards. All native and manufactured silver contains gold, copper, iron or arsenic. These metals have a great affinity for silver, and cannot be entirely separated from it in the smelting and refining operations. Native silver is usually, however, an alloy of silver and copper, the latter ingredient often amounting to ten per cent. It is also alloyed with gold, and sometimes with bismuth. Before the blowpipe it fuses easily,

and affords a globule which becomes angular on cooling. It dissolves in nitric acid, from the diluted solution of which it is precipitated by putting in a clean piece of copper. It is easily distinguished by being malleable. It may be known from bismuth, and other white native metals, by giving off no fumes before the blowpipe, and by affording a solution with hydrochloric acid, which becomes black on exposure.

Sulphuret of Silver, or silver glance, is the most common of all the silver ores, and is found in the form of crystals, hairs, and needles, or like wire twisted into nets, and in flat plates, and in amorphous, or shapeless masses. It has a dark gray color, and is malleable and easily cut with a knife, like lead. It is not elastic like metallic silver. The clean cut looks like metallic lead, but soon becomes covered with a film of various colors. It is a soft heavy ore, having a specific gravity of 7¼ to 7½, and hardness=2 to 2½, and, when pure, contains 87 per cent of silver, and 13 per cent of sulphur. It gives off a sulphurous odor before the blowpipe, and finally yields a globule of silver. It is soluble in nitric acid, and, from a diluted solution of which, it can be precipitated by putting into the solution a piece of clean copper. Sulphuret of silver, and all the silver ores, are found in rocks of all ages, except in the coal formation: and always accompanying the ores of copper, lead, antimony, gold, arsenic, and others, along with quartz, calcspar, heavyspar, or Baryta, manganese, pyrites, and other minerals. It is a remarkable fact, that silver occurs more abundantly where mineral veins cross, or meet each other, than in other places, or in the finer ramification of a vein.

This ore is abundant in the gold region of the Southern States, where it appears in heavy veins, associated with other metallic ores; but the only one (of the many deposits of this kind which occurs in the United States) being worked to any extent, up to a late period, is the Washington mine—unless there has been some lately started in California. The silver ores of that gold region are imbedded in a gray, blue, or brownish-black mineral, composed of from 30 to 50 per cent, of sulphuret of zinc, from 5 to 10 per cent. of galena, in small crystals, some iron pyrites, copper pyrites, sulphuret of tin, and in some cases a little arsenic. The amount of silver in these ores varies from 12 to 60 oz. to the ton of crude ore, and is worth $2 (gold) per ounce, on account of the large amount of gold with which it is alloyed. These ores are very rich in gold, and some of them yield it by simply being pounded and washed.

Sulphuret of silver and antimony occurs with other silver ores, and contains sulphur 16.4, antimony 14.7, silver 68.5 and copper 0.6per cent. It is formed in right rhombic prisms, in compound crystals, and massive. Its streak and color is iron-black, and its hardness 2 to 2½, and specific gravity 6¼. Before the blowpipe it

gives off an odor of sulphur and also fumes of antimony, and yields a dark metallic globule, from which the silver may be obtained by means of the addition of soda. It is soluble in dilute nitric acid, and the solution indicates the presence of silver, by silvering a plate of copper, when placed for a short time in it. Its black color, and, more decidedly, the fumes of antimony given off before the blowpipe, will readily distinguish it from the sulphuret of silver.

Chlorid of Silver, or Horn Silver, is not of so general occurrence as the antimonial sulphuret, but it appears in almost every place where silver is found, and occurs chiefly at the out-crop of veins, along with native or sulphuret of silver. It appears in cubes, massive, columnar, and often incrusting; has a gray color, passing into green and blue, and looks somewhat like horn or wax, with a resinous lustre, passing into adamantine, often exhibiting all the colors of mother-of-pearl, and cuts like wax or horn. When pure it contains 75.3 per cent. of silver, and 24.7 per cent. of chlorine. It fuses easily in the flame of a candle, and emits acrid fumes, and with the blow-pipe affords silver easily on charcoal. The surface of a clean iron plate rubbed with it becomes silverized. This is a very common ore, and is extensively worked in South America and Mexico, where it occurs with native silver. It is also found in Cornwall, Saxony, Siberia, Norway, and the Hartz. There are, besides those enumerated, a great many other silver-bearing ores, but, although valuable, their appearance is very rare, and they are more sought after as cabinet curiosities, or objects of science, than as silver ores.

Silver has been found in many of the lead and copper ores of both Upper and Lower Canada. At Lake Superior, in Prince's mine, it was found in calcspar, mixed with copper and a small portion of gold; and in like manner, silver, copper, and gold, were found in pyrites, on the 17th lot of the 7th range of Ascot; and in a quartz vein, which occurs at the rapids of the Chaudiere, in St. Francis, Beauce County, in Lower Canada, silver, lead, and native gold was found. The lead appeared to be very rich in silver, a sample yielding no less than 256 ounces to the ton of ore.

These and many other interesting details respecting the richness of the silver ores of Canada, can be found in Sir William Logan's Geology of Canada. Their occurrence in the gold fields of Upper Canada may be looked for with some prospects of success, and more especially in galena, which, as before remarked, if not found in commercial quantity, to make it available as a lead ore, may, in that formation, be expected to be rich in silver, and therefore of importance as a silver-bearing ore.

Mica occurs in some abundance in the Laurentian rocks of Canada, and has been found in considerable sized sheets in many

places, more particularly in the neighborhood of the Ottawa river, and the head waters and lakes of the Gull and Black rivers. It is usually found in finely disseminated particles in the gneiss rock, giving it a lamellar or easily-splitting structure, but is occasionally met with in quartz or other vein stones, in highly cleavable, flat, foliated masses, from a few inches to two or three feet across its face, and one to several inches thick. These masses can be split into very thin leaves, which are elastic, tough, more or less transparent, and of various shades of pearly color, from white, through green, yellow, and brown to black. Its composition is silica 46.8; alumina 36.8; potash 9.2; peroxyd of iron 4.5; fluoric acid 0.7; and water 1.8. It is highly refractory, and infusible before the blow-pipe, but becomes opaque white. On account of its toughness, transparency, and thinness of folia, it has been used in Siberia for glass in windows, and in the Russian navy it has been employed as a substitute for glass, on account of its not being liable to break or fracture from concussion. It is in common use for lantern and stove windows. It is worth from $1.00 to $2.50 a pound, according to size, color, and transparency, and may be successfully searched for, and obtained, amongst the Laurentian rocks of Canada, more particularly in the places above indicated.

Beryl—Emerald—usually occurs in long six-sided prisms, without regular terminations. Its color is pale green, passing into blue and yellow, excepting the deep and rich green of the emerald. Its lustre is vitreous and sometimes resinous. It is a hard, brittle mineral, being 7½ to 8 in the scale of hardness, and is transparent to subtranslucent. The *Emerald* includes the rich green variety, and owes its color to the oxyd of chrome. Beryl especially includes the paler varieties, which are colored by the oxyd of iron. *Aquamarine* includes clear Beryls of a sea-green, or pale-bluish, or bluish-green tint. Beryl consists of silica, 66.9; alumina, 19; gluciana, 14.1. Emerald contains less than one per cent. of oxyd of chromium. The hardness of this mineral will distinguish it from apatite, (a phosphate of lime,) and this character, and also the form of the crystals, from green tourmaline, and its imperfect basal cleavage from euclase, (a pro-electric species of silicate of allumina and gluciana,) and topaz, a fluorid of silica. The finest emeralds come from Grenada, where they occur in dolomite, a magnesian carbonate of lime. A crystal from that place 2¼ inches long, by about 2 inches in diameter, is in the cabinet of the Duke of Devonshire, and though full of flaws, and partially unfit for jewelry, has been valued at $800. A more splendid, but much smaller specimen, belonging to a Mr. Hope, of London, cost $3000. The finest Beryls come from Siberia, Hindostan, and Brazil, and, some of them, are as large as a calf's head. Sir William Logan remarks of this mineral:—"In the Laurentian system, granitic veins, with tourmaline, ziron, and mica, the associates of Beryl,

are met with." According to Dr. Bigsby, Beryl is found in well defined pale green crystals, with black mica, in a porphyritic granite, associated with gneiss and mica schist, on the east side of Rainy Lake, 280 miles to the west of Lake Superior. As these valuable minerals, and their associates, chrysoberyl, tourmaline, ziron, &c., occur in the gneiss and granitic rocks, they should be sought for in the Canadian Laurentian rocks, while a search for other minerals is being prosecuted.

Labradorite usually occurs in cleavable massive forms, and has a dark gray, brown, or greenish-brown color, with usually a series of bright chatoyant colors from internal reflections, especially blue and green, with more or less of yellow, red, and pearl-gray. The lustre of the principal cleavage face is pearly, while that of the other faces is vitreous. Its hardness is 6, and its specific gravity 2.69 to 2.76; and its composition, silica 53.1; alumina 30.1; lime 12.3; soda 4.5; water 0.5. Before the blow-pipe it fuses to a colorless glass, and is entirely dissolved by hodrochloric acid. It differs from feldspar and albite (a compound of silica, alumina, iron, and soda, &c.,) in containing a large per centage of lime, by its dissolving in hydrochloric acid and its beautiful deep-seated colors and their reflections. It is a constituent of some granites, and was originally brought from Labrador, hence its name.

Labradorite receives a fine polish, and, owing to the chatoyant reflections of rich and delicate colors, the specimens are often highly beautiful, and sometimes used in jewelry. This beautiful mineral occurs in many parts of the Laurentian formation, from the coast of Labrador to Lake Superior, and probably much further to the north west. The specimens collected in Canada by Sir William Logan, and now in the Geological Museum at Montreal, are very beautiful, and from experiments caused to be made by that gentleman, it was found that Labradorite rock could be readily sawed and manufactured at a cost a little above that of ordinary marble, certainly not more than its great beauty and durability would amply warrant and justify. A very large deposit of that mineral occurs on the Georgian Bay, forming many small islands, and the coast line of the main land for a distance of five miles, which affords excellent facilities for being sawed into slabs and blocks, and for exportation.

Besides the minerals we have enumerated, there occurs numbers of others, of great value and importance throughout the length and breadth of Canada, of which it is beyond our limits to speak. These are, properly, subjects for a more extended and scientific treatise than this essay pretends to. We have merely confined our observations, as much as possible, to the more valuable and prevalent minerals already known to occur, or that may hereafter be found, in the ancient subcrystalline and metamorphic

rocks of the Laurentian formation, in which the precious meta has so recently been discovered. This mineral will be so extensively sought after by explorers, through that formation, during the succeeding season, that we have deemed it advisable in the highest degree to draw their attention to the fact of the existence of other equally valuable minerals in those rocks, and which, if not gold, can, in a great majority of instances, be more readily and profitably converted into gold, through the regular channels of commerce, than the latter can be extracted from its primitive or native bed.

In exploring for minerals, the first thing necessary is to ascertain whether there be any, and of what description, in that locality. The next consideration will be, in what particular spot, rock, or vein-stone, they are most likely to be found. In order to success, we must have a knowledge of these rocks, as it multiplies and facilitates our operations. For this purpose, some knowledge of mineralogy is necessary, whereby we may know the rocks or veins, when we see them. To supply this want to those who have little or no knowledge in these matters, we have given such a description of the prevailing rocks of the Canadian gold region, as will enable the explorer to detect and identify them when found. Where the veins run parallel with a uniformly inclined or horizontal strata, there is no difficulty in finding a vein; but where the mineral-bearing vein traverses corrugated and disturbed strata, at various angles of inclination, more or less defined, the object is not so readily attained. The veins, however, in the central part of the Upper Canada portion of that formation, have two general bearings; that is, the one from south-west to north-east, and the other from the north-west to the south-east. The former is more abundant than the latter, and they both belong, more particularly, to the quartz class, in which gold is found. Feldspatic veins, like the quartz veins, keep a general straight course, and are, like the others, of variable width, and are easily distinguished, by their camparative softness and darker color, from the quartz veins, which are generally white, and will strike fire with steel, while feldspar will not.

When fragments of ore are found at the bottom, or on a hill-side, it is very evident that the vein-rock, from which the fragment came, has a higher location, and should be searched for higher up. If the fragments of mineral are found on level ground, and the specimen is sharp and unworn on its angles, the vein is not far off. If rounded and worn in appearance, it may have been a drift, and brought from a great distance. In this case, no matter how rich, it would be useless to search for it. If fragments of mineral are found in a stream, the veins which supplied them must be higher up the river. Heavy materials do not drift far, and, in consequence of their weight, are easily destroyed. Gold never drifts far in a stream; it is always found close to its source. If the current of

water is strong enough to move grains of gold, it soon rubs them into such a fine dust that it can be carried off by the most gentle current. Therefore, gold is seldom found in quantity in the beds of streams or rivers. Native metals, and sulphurets of metals, are always found near their source, because they cannot move far without destruction. The Laurentian formation is so little covered by drift, or sedimentary matter, that its rocky strata is very much exposed; therefore, little if any difficulty will arise in finding and tracing out a vein-rock, and the search by *trench*, *drift*, *shaft*, and *boring*, may in most, if not in all, cases be entirely dispensed with. When, however, a gold-bearing quartz vein has been discovered, and it is desired to test its value at a depth, a bore-hole may be advantageously sunk in the vein; or, if the vein has an inclination, or a dip, the hole should be commenced at such a distance from its *upper* side, and in such a place, where a prolonged plumb-line would be most likely to reach the vein, at the required depth from the surface. When the hole has been sunk directly through the quartz-vein, from the top, the bore-meal, or pounded rock, will serve as a test of the richness of the vein, as the work progresses; and, in the other case, when the drill strikes the quartz beneath, its meal will, in like manner, indicate the richness of the vein. The operation of boring and testing for minerals, as described above, may be conducted in the same manner as boring for oil, salt, or artesian wells. Boring an artesian well by the aid of a rope and heavy spindle is a very simple operation, but requires considerable practice, which a mere description cannot supply to those who undertake it.

With the exception of iron, minerals are either scantily dispersed in sand or soil, or exist in small veins, traversing and ramifying the rocky strata. Metals and metallic ores, generally, have a greater specific gravity than soil or sand, and this forms the principle upon which to base the first examination. If sand or soil is to be examined, we must select a spot where we suspect the existence of minerals. This may be at the bottom of a bank or in the bed of a creek, or river, or in any place where a current of water would be likely to have deposited a heavy substance. If it should be sand, clay, soil or gravel, it should be obtained from as great a depth as possible, and put into an iron or tin pan, about ten or twelve inches in diameter, and from two to three inches deep, having a straight bottom, without bend or curve, and the sides forming a sharp and well defined angle with the base. Such a pan should be filled with the sand, or material to be examined, and then immersed in still water, either in a large tub or in a pool, or in a creek where there is little or no current. Washing under a pump, hydrant, or in a current of water, is not recommended; for some of the mineral, which it may be desired to save, may be carried off. The pan must then be submerged, and filled with water. The sand must then be stirred with one hand, while the

other holds the pan, and, when the mass has been well worked through, and any lumps of clay well pulverized and dissolved, to liberate any particles of mineral it may enclose, the muddy water in the pan must be poured off, and the pan filled again with fresh clean water, re stirred, and poured off. This process must be repeated until all the fine light particles of clay and sand are washed off. When this has been done, the bulk in the pan will be considerably diminished, when the pan must be held horizontally, and only so much water admitted as will cover the sand. By holding the pan with one hand, and shaking it with the other, all the heavy particles will sink below the sand. And, if one side of the pan be gradually lowered while being shaken, it will allow the light particles, even if quite large, to pass off with the water when the heavy metal will settle in the corner of the pan. If there is much quartz sand in the pan covering the particles of heavy metal in a thick layer, the greater part of it may be removed and drawn out by one of the fingers, care being taken, at the same time, not to throw out any valuable mineral. It is not necessary to use both hands in shaking the pan; a little practice will enable the operator to shake with one hand and wash with the other. By this means the quantity of material under examination is reduced to a very small bulk, and may be washed off almost to the last grain, if the shaking operation has been well performed. In the corner of the pan there will remain more or less metal, or metallic ores, in case there was any in the sand. By putting a small quantity of water in the pan, just enough to cover the sediment, and giving the pan such a motion as will produce a gentle current in the corner of it the minutest particles of metal, even one particle, and that invisible to the naked eye, may be secured. If there are any particles heavier than those which are visible, they will be brought to light, because the lighter particles of the mass are carried forward by the current of water, and the heavy ones remaining behind become gradually exposed. In the corner of the pan may now be seen a string, or some one or more heavy particles, which may be examined by a lens if they are too small to be detected, or are forms which cannot be distinguished by the unaided eye.

This is the usual process adopted by explorers in finding and washing sand or gravel to obtain gold, platinum, diamonds, tin, and lead, and to determine their existence in any locality. Of course there are other appliances and modes adopted in the extraction of the precious metal on a large scale, both by crushing, sluicing, and amalgamation, but they are only introduced into gold regions by capitalists and mining companies after due preparation, and the fact of the existence of the precious metal has become well established and gold bearing property secured, but never during exploration or preliminary investigation. Gold is easily detected by its bright lustre when not discolored by amalgamation, or in alloy with other metals, or sulphurets, in which cases it had better

be submitted to an examination in the usual way, by assay. Platinum is known by its lead color and great weight, tin by its dark gray, often black, colour, and lead by the lustre and crystalline form of galena. Other metals can hardly be distinguished from each other in that way, because their sulphurets are easily oxydized, and escape in this way without being recognized. Diamonds are easily detected by their sparkling brilliancy if the pan is held in the direct rays of the sun. Minerals which cannot be distinguished by the eye had better be subjected to those trials which have already been mentioned, or submitted to an experienced metallurgist.

Minerals and Metalic ores extracted from veins or beds must be selected so as not to have an admixture of different kinds in the one examination. Veins belonging to the older rocks always contain a variety of mineral substances, but up in the more recent formations, much variety is not to be expected. If a specimen from one of these veins is subjected to an examination by the eye, or by the lens, the color, lustre, and crystals, are observed, and if we cannot decide what the mineral may be, we try its weight and gravity. Experience in judging of specific gravity by feeling, is of great service and vastly facilitates the determination of the character of a mineral. Water is the comparative standard of weight, whereby the weight of other matter is compared. It is placed at 1 : that is one pint of pure water, at a temperature of 60 degrees, weighs one pound, common brick is placed at 2, quartz 2½, sandstone 2 to 3, iron ores 3 to 4, heavy spar or Barytes 4½, tin ore 6, galena 7, gold 19, and platina 21 : that is, 1 pint of platina will weigh as much as 21 pints of water, and so with all the others. From this we may extract some leading features which may be used as a standdard of comparison of other materials. In connection with the above, their is a scale of hardness adapted in mineralogy, the application of which will also much facilitate the determination of minerals. This scale ranges from No. 1, for talc, which is a very soft mineral, to No. 10, for the diamond, which is the hardest of all known substances, and will be found mentioned in connection with the majority of the minerals treated of in this work. Besides these, there is also the taste and smell. The hardness of a mineral is usually determined by a small hard file, but reliance is not to be placed on this test, as the same mineral often varies in hardness.

If the specimen is white, or of a whitish color, and soft, it may be clay, chalk, limestone, or some metalic oxyd, and should be roasted, by exposure at first to a gentle heat, and afterwards to a cherry-red. If it retains its white color and slacks in water like quicklime, it is chalk. if not, it may be clay, but if neither clay nor chalk, it may be a metalic oxyd. If it is hard, but still white, and adheres to the tongue, it may be clay-slate, clay, fire-clay, or argellaceous iron ore, (iron holding clay), and should be pounded and roasted, when the quality may be ascertained. If it does not

adhere to the tongue, it may be a metallic oxyd or carbonate, for most of the carbonates are white. If crystalline in form, it will require the aid of an expert mineralogist to decide on the proper class to which it may belong, and even then the result is very doubtful. The only positive method of deciding the queition is, by roasting the specimen. If it is soluble enough to impart a taste to the tongue, it may be common salt. Saltpetre has a disagreeable sweet taste, alum a sour astringent taste, and white copperas, a sour taste, much like ink.

If the specimen under examination is yellow and friable, (pulverulent) it may be, and in most cases is, the hydrated oxyd of iron or yellow ochre. Some lead and zinc ores have a yellow, and dirty yellow color. The former are regarded as mere curiosities, and the latter is of a compact aggregate form, and always of a dirty color. If it has a yellow color, is hard, crystalline, and of a metalic lustre, it is, probably, a metalic sulphuret; this can easily be determined by roasting.

The red class of minerals embraces a large variety, in which iron predominates. There are masses of red iron ores of every variety of form and color, from a faint rose-colored clay-ore, to the dark crimson, and almost black crystalline oxyd. If unable to determine to which class the specimen belongs, by the sight, we have no other recourse remaining but to roast it. Cinnabar is red, and, like zinc, inclines to yellow or orange, but can be distinguished from zinc by its more lively color, and from iron by its shade of color. Zinc has a shade of yellow in its composition, while iron inclines to brown. There is also a bright fiery red copper ore, but it has a much greater specific gravity than the above mentioned ores; and there are red-lead ores, which have about twice the specific gravity of iron. There are also red silver ores, ores of antimony, and other red minerals, but these are substances, the character of which, if any doubt exist, should be determined in the labratory of a professed mineralogist.

Brown colored minerals predominate in mineral deposits, and, when the specimen found is of that color, it may be a hydrated oxyd of iron, in which case it will yield a yellow powder by which it may be distinguished from other minerals. The *sulphuret of antimony* is brown, but is easily known by its well developed crystals, or crystalline fracture; the crystals are developed in long prisms, or pyramids, and the color always inclines to blue. The *oxyde of tin* is also dark-brown, but is very hard, has little lustre, and is extremely heavy. The *sulphuret of zinc* is also brown, inclining to blackish-brown, and soft enough to be scratched with an iron. *Brown cinnabar* is a species of sulphuret of mercury contaminated with vegetable matter, carbon, or bitumen, and is quite common among the ores of mercury. *All the ores of manganise* are Brown, more or less inclined to black; they are

found crystallized, and amorphous, in masses of earthy texture. *There are many lead ores* of a brown color, but they are usually accompanied by galena, and may be easily known. *Chrome ore* is also brown, but is easily distinguished by the use of potash when roasted along with the pulverized ore. The potash will take up the acid, and, by saturating the charge, after roasting and cooling, the color will determine the chromic character of the specimen.

Black colored minerals are the most prominent in the whole range. *Magnetic iron ores* are all black, and are distinguishable from all other substances by their affinity to the magnet. If a magnet cannot be obtained, the blade of a knife, well rubbed by the end of a fire poker, or on the powder of the ore, will impart sufficient magnetism to the blade to cause it to attract the finely powdered ore. *A violet-black hydrate of iron* is also found, but always accompanying *brown hematite;* it appears in concretions. A *crystallized black oxyd of iron*, having a feel like plumbago, is very common. *A black ore of copper* is also found, but it is a curiosity, generally forming but a film of black velvety oxyd over another ore of copper. Most of the common *manganese ores* are black, but usually inclining to a brown, and, in some instances, to a blue. *Metalic silver* also appears in black masses, or concretions in great variety, but is maleable, and when cut with a knife exhibits metalic silver.

In conducting the above, or any examination, of mineral species it is necessary to be provided with a good magnifying *lens* of one, or better, one and a half inches in diameter. The specimen supposed to contain the mineral should be broken, to afford a fresh fracture; if by close examination no difference in the texture, or sprinkling of foreign matter can be detected in the mass, it may be considered of uniform composition. If however grains, or crystals, of other minerals are detected in the main mass, they should be examined as to their color, lustre, hardness, and chrystaline form; and, if this is not sufficient to determine the nature of those particles, the whole mass should be pounded and washed. By this means we will obtain a larger quantity of particles, which may be more readily recognized; and, if not, there is no other plan left but to pound and roast it. Minerals examined by the eye or lens should be slightly moistened, to draw out more vividly their colors and lustre.

When gold bearing ores are under examination by the aid of a lens, the greatest caution is requisite not to decide too hastily. Ores containing gold in very minute particles are the most difficult to examine; for a spec of the sulphuret, or oxyd of iron, will often mislead the best observers. If, apparently, a spec of gold is detected in a piece of rock, the specimen should be turned in such a way that a direct ray of light may fall upon the grain, or par-

ticle, from all directions, and it should then be minutely inspected in every possible way. If, on turning the specimen round, no portion of the surface color, curvature, or lustre, is interrupted, but that it retains all, in complete uniformity, we may, provided the specimen be moist, believe the speck, or specks, to be gold. If the particles exhibit a perfect plane smooth surface, or a sharp angle, or is very brilliant, its identity with gold may be questioned; still, it may be gold, which can be decided by touching it with the fine point of a pen knife. *A metallic sulphuret* will not take an impression from steel, but gold will. The surest and most certain way is, however, to pound the rock into a fine powder, carefully wash it from all rocky matter, and then examine the pan, if necessary, by the aid of a lens, to ascertain if there be any particles of gold in the corner of it. Particles of gold exhibit a uniform color, and are either flat, spherical, spangles, or round irregular grains; while particles of sulphurets, or other minerals have crystalline forms, refract the light more strongly and shew planes and angles on the surface.

Mines are the depositories in which the subterraneous treasures of the mineral kingdom have been placed by the bounty of the Omnicient Being, to be developed and utilized, at progressive periods, by intelligent man; and *mining* is an art in which all the lights of science, all the capacity of mind, and diligence of man, must be brought to bear, and in which they can find their application. The few mining operations that are being carried on in a country so rich in mineral wealth as Canada, is somewhat surprising, and are of too limited a number, and of too recent an origin, to present any masterpieces in the art, or afford any instruction. It requires ages, and even centuries, to develope such subterraneous caverns and structures as are at this day to be found in the full operation of developement in the old world, in South America, and in Mexico. In these old subterraneous mines there is poetry—a high, religious poetry—the miner, in his lonely chambers, is constantly reminded of the bounties at his disposal, and the assistance he requires from a higher power than what poor puny man can bestow. But we are travelling beyond bounds. It is not permitted us to luxuriate in descriptive mining, to its fullest extent. This we exceedingly regret; but, as our aim is to be explicit, brief, and useful, and as there can be no immediate use, in the present stage of progress, in the development of our mineral wealth in this country, in describing the highest cultivation of this art, it would be wasting the time of the reader without any corresponding advantage, to extend this essay any further than its practical utility will warrant.

Mineral deposits are rarely discovered except by actual exploration and search. There are leading features in the geological structure of a country, and the study of the science of geology

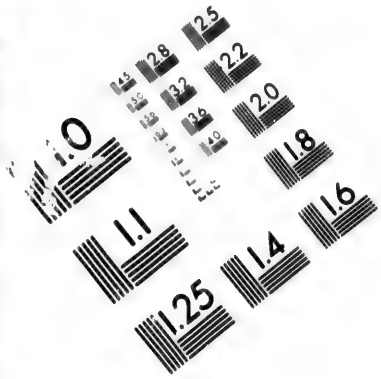
will furnish us with instructions sufficient to enable us to determine what kind of minerals may be found in a certain description of rock, or formation, and those which cannot; but it cannot, and should not, be expected to do more than give us an approximate idea of the locality and its boundaries, in which those certain classes of minerals, that geological research have determined to belong to it, to the exclusion of all others. For, it would be labour in vain to search for a certain mineral substance in a rocky structure in which it could not exist. Therefore, a knowledge of geology, sufficient to distinguish the rocky formations, and to know the class of minerals belonging to, and generally found accompanying each, is indispensible to success, and the saving of labour.

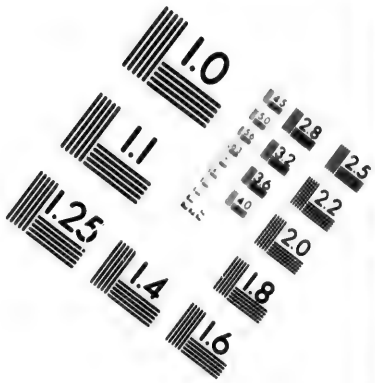
Among the many falacies had recourse to by the ignorant, in endeavouring to determine the location of the more valuable mineral deposits, are those derived from unimportant circumstances, such as the issuing of mineral springs, the emission of vapors from crevices in the rocks, the more rapid melting of snow in one place than another, and the presence of certain species or kinds of vegetation. The divining-rod, and the secret compass, made of load-stone, or magnetic iron pyrites, electrobiology, and many other contrivances of a similar foolish nature, are also absurd follies. Such means only tend to support the pretensions of the deceiver and impostor; and, it is to be regretted, have often been the cause of superstitious and ignorant people engaging in researches of the greatest folly and absurdity in their nature, and which as invariably resulted, disastrously and ruinously to the credulous treasure-hunter.

Indications of a mineral deposit is either indirect or direct. Geology points out the indirect indications. We cannot find water by digging into quick-sand, unless we dig through it; bituminous coal cannot be found in granite, nor gold in the coal formations; tin does not exist in lime-stone, nor carbonate of iron in the primative rock. If such anomalies do happen, it is merely an exception to the general rule. Positive or direct indications of minerals are the finding of a specimen, even though it is not in *situ*, or in its proper place; the frequent occurrence of fragments of minerals strewed over the surface, and the actual discovery of a vein or deposit in situ.

ASSAYING.

It is not my object in writing this treatise, to describe the operation of assaying so perfectly as to afford a qualitative and quantative result, similar or equal to a chemical analysis. We intend to





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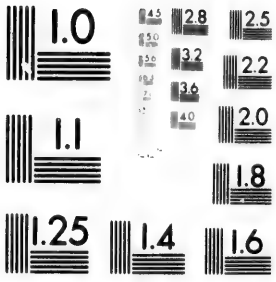

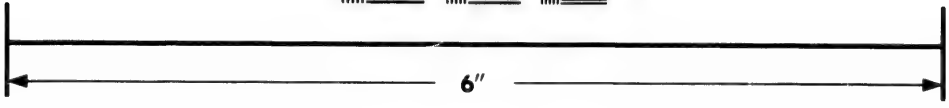

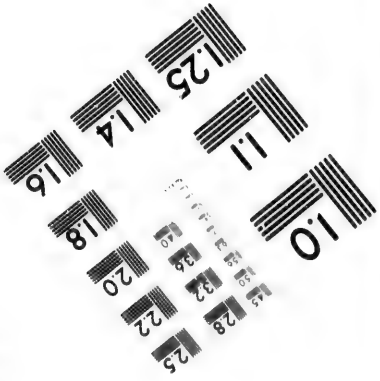

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go so far only into the subject as will enable the explorer to form a tolerably correct estimate of the value of the ore which he may find, and the components of which he may desire to determine. Were we to do otherwise, this work would become too cumbrous, and the facilities and requirements, too few and too remote, to be of any avail when the would-be operator was far in the interior. In all cases, however, where any doubt arises respecting the quantity, quality, or value of an ore, which the explorer cannot sufficiently determine, the only way to arrive at a satisfactory result is to mark the place where the ore was obtained, and have recourse to a professional assayist, or chemist, with a fair average specimen, and have it assayed. However, we will state that the operation to be performed is to reduce the ore, whatever its nature may be, to the metalic state, (if of a metalic nature,) and then decide its value. To perform a dry analysis or assay of this kind, crucibles are required for the smelting of the ore, and cupels for ascertaining the presence and amount of the more precious metals it or they may contain. These crucibles can be most advantageously purchased in a drug store; but if the explorer is too remote to have easy access to such a place, (which is not likely in the Canadian gold regions,) he must resort to their manufacture, or at least to a substitute for them. Crucibles suitable for the explorer's purpose should be about four inches high, and three inches wide at the top. The material of which crucibles are generally made is plumbago and fire clay, which contains a larger portion of sand. In many instances, an iron pot will serve the purpose, but if it is required to have a more refractory or fire proof article, and the explorer has not the means of access to get them, let him find some white, tenacious, plastic clay, free from lime, which can (on trial) stand the fire without melting. In the next place let him break up an old fire brick, piece of porcelain or, chinese ware, or gray stone ware. These must be pounded into a coarse sand, and mixed with the burnt clay. If these latter are not obtainable, white quartz, pebbles, or pieces of stone, free from lime, are substituted. They must be heated to redness, and suddenly thrown into cold water, after which they must be pounded, as before stated, and are then ready for use. This coarse sand, made from one or all of the ingredients mentioned, is mixed with as much fire clay as will make it adhere together. Too small a proportion of clay has a tendency to weaken the crucible, and two large a quantity makes it liable to form cracks and pores. The mixture of clay and sand must be well worked and kneaded by hand, and the desired shape of the crucibles moulded over a pattern of proper shaped wood, around which a sheet of wet paper may be placed to prevent it from sticking. The paper may be left in the crucible, as it will protect the clay against the first influence of heat, and prevent it from cracking. It will burn out in the subsequent baking of the crucible. The bottom of the crucible should

be about half an inch, and the sides from two to three eighths of an inch thick. When the form has been given, they should be allowed a few days to dry, in a gentle heat, as it takes some time for the water to evaporate from the clay. When sufficiently dried they must be subjected to a strong red or even white heat. The baking may be done in a stove, or grate, or open fire; the crucibles should be piled in the centre, and the fuel, coal or dry wood, laid around them. They should be allowed to remain in the fire until it burns out and, if the baking has been done in an open fire, should be well covered with ashes to protect them from the sudden rush of cold air which will occur when the fire is exhausted.

The Cupel is another apparatus for smelting; it is a small, flat crucible of one or two inches in diameter and about three quarters of an inch high, flat at the bottom, and having at the top a flat concavity, in which the metal is assayed. The cupel is made of finely-pulverized bone ashes, wood ashes, or marl. The first is the best, or the first and second mixed together. These ashes must be well pulverized, sifted and mixed with as much water as will cause them to adhere slightly. The ashes should then be pressed into a small tin cup, or a simple ring of tin and a convex depression formed on the top like a watch glass. As the mass has but slight adhesion, it requires to be handled very gently; for this reason a piece of paper may be laid around it. They should be porous but close enough to prevent the infiltration of pot metal; and, on this account, too much and two little water will prove alike injurious. A strong pressure is necessary in forming a Cupel. Fresh made cupels can be air dried, which can be done on the top of a common stove, or in any other warm place, after which they are ready for use.

Smelting.—Metallic mineral ores are always a combination of metal and oxygen, or metal and sulphur. These latter must be changed into the first, and made an oxyd, by roasting before they are exposed to the reducing process, or smelting. Oxygen readily combines with carbon in a heat sufficiently intense for smelting; hence, all the metallic oxyds are reduced by carbon. Sulphur has a great affinity for iron, and, the metallic sulphurets, are therefore, always melted along with metallic iron, which takes up the sulphur and liberates the metal that was at first combined with it. The ingredients made use of in smelting, as well as the ore must be reduced to powder and finely pulverized so as to form a fine, impalpable powder, or dust. Then the ore, fluxes, and material used for reduction, are sometimes all mixed together, and, at other times, they are put into the crucible separately, the ore to be smelted must be as pure and as free as possible from foreign matter, and in all cases, the ore, after being coarsely pounded, should in every instance be washed, to purge it of all impurities. *Smelting Furnaces* cannot be every where obtained.

If they could, their use would be preferable to the means proposed below for supplying their place. It is to be presumed, that those who are willing to incur the expense of building a smelting furnace, have the knowledge necessary for that purpose, without resorting to the necessarily narrow limits of this work for information, and we will therefore pass that matter by and proceed to the details of a method in substitution. For smelting lead, and almost all other metallic ores except iron and tin, a common coal stove will give out sufficient heat, particularly if it be provided with a clay lining, or partially closed with clay. A common coal fire-grate constitutes a good smelting furnace. The grate may then be reduced in size, by filling in brick at both ends, so as to reduce the interior dimensions to about one foot in length. The space above the grate, which furnishes the draft, may be closed by a sheet iron, or brick covering, leaving only a small opening for supplying the fuel and inserting the crucible. This small opening may be closed by a brick. Such a grate, or pair of tongs, an iron poker, crucibles, ore, and fluxes, are the only requisites for the performance of successful operations.

Assay of iron ores.—To smelt or assay iron ore by fusion, is neither a simple nor an easy operation, especially if it is intended to separate, not only the iron, but all other ingredients, and make a quantative assay. Iron ores are easily recognized by their changing to a red color in roasting, and there will be no need of smelting, if it is not desirable to find out the quantity of iron in the ore. To do this the ore must be brought to the highest state of oxydation: if it is not naturally a red oxyd, it must be roasted to make it so. The ore must then be finely crushed, and the fluxes also pulverized, and five hundred grains, which is a little over one ounce, mixed with one hundred grains of powdered limestone, one hundred grains of dried, or still better, melted borax, and one hundred and fifty grains of hard charcoal. All these ingredients must be well pulverized, dusted, or run through a fine silk sieve, and then mixed together. If borax cannot be obtained, a little common salt and a small quantity of potash may be added to the lime, but the results are not so certain as when borax is used. The addition of lime to all ores is not always correct in principle, as some ores already contain it, and it is only necessary to add it, in greater or less quantity, to those ores which do not already contain enough, or hold it only in insufficient quantity. If this ore contains lime, it will be advisable to use only borax and carbon or charcoal in the smelting which succeeds in all cases; the only difference being, that, the assay will not be so correct without as with the addition of lime. In the assaying of iron, good crucibles are necessary, and those made from black lead are, for many reasons, preferable to those made from clay. The materials for smelting must be well dried before using, and

the crucible should be dry and warm before the materials are put into it. The mixture, when put into the crucible, should be pressed down gently, the remainder of the space filled with coarsely pounded charcoal, and the whole covered by either a slab of clay, a piece of fire-brick, a piece of anthracite, or charcoal, and the whole charge to be tested should never more than half fill the crucible, as the mass will boil as soon as melted, and may run over the sides of the pot, if sufficient room is not left. The crucible should now be placed on a piece of fire-brick, in the furnace, so as to elevate it about three inches above the bars of the grate, and firmly fixed, and the fire kindled and kept at a brisk heat for at least one hour, after which the furnace must be again filled with coal, covering the pot and its lid, the door shut down, and the most intense heat generated which the fuel is capable of producing. The under bars of the grate should be frequently cleaned and a liberal quantity of air supplied. If charcoal is used, the fire must be replenished as the coal is consumed. If the draft is not sufficient for the consumption of anthracite, it may be mixed with charcoal. The second heat cannot be too strong and should continue for nearly one hour; after which with a pair of tongs the crucible can be removed from the fire and placed upon a heated brick, otherwise, if placed, while heated, upon a cold or damp place it is liable to crack, and the assay may be lost. When the crucible has been slightly cooled but is still of a white heat, give it a few motions up and down, placing it gently but firmly upon its foot piece. This motion is necessary to bring down and collect the particles of metal which may be suspended in the melting stage. When cold the crucible may be broken and the button of metal will be found in the bottom. If the heat has not been strong enough, or the flux has not been sufficient, much of the iron may be found in small globules in the slag. In this case the slag should be pulverized without breaking its grains, and the pounded mass washed in the wash pan where the grains of metal will remain after the pounded slag has been washed off. An experiment terminating as badly as the above, would be considered a failure, not because the metal was not gathered together in one button, but because a large portion would remain in the slag in the form of an oxyd. In all such cases the operation should be repeated. There are many causes of failure, to enumerate which and their remedies would necessarily carry us far beyond the limits of our work without any practical benefit to those for whom it is designed, suffice it to say that we must be cautious in the use of potash or soda, and it will be better if their use can be avoided, as borax and lime should be quite sufficient to finish any assay of iron, and it will be better and more satisfactory, to repeat the assay where a partial failure such as the above occurs. When a satisfactory result has been obtained, the button of metal, found in the bottom of the crucible, should be

cleansed and freed from slag by the gentle use of a small hammer and then weighed. The weight of this button will give the proportion of metal contained in the ore. When the assay contains 500 grains, and the button weighs 100 grains, the ore contains one fifth or 20 per cent of metal, and so on, in proportion to their relative weights. After the button has been weighed, it may be broken, and the fresh fracture will indicate the quality of iron which may be produced from the ore in large or extended operations.

Assay of Copper ores. If the ore is a mixture of native copper and rock, the mineral should be coarsely pounded, and most of the rocky debris washed off. After this it must be once more pounded, mixed with a small quantity of potash or soda, and exposed to a strong heat in a clay crucible without any addition of Coal. If the fire is strong the copper button will soon be formed; fifteen minutes or half an hour is generally sufficient to smelt this kind of ore. Copper ores, of whatever nature they may be are improved by roasting, which expels the larger portion if not all the volatile matter contained in them. The roasting must be performed by a gentle heat, and the ore repeatedly pounded, after which it is smelted along with black flux and borax.

Black flux is a compound of carbonate of potash (pearlash) or carbonate of soda and carbon, (charcoal) *and is made in the following manner.* Two parts of crude tartar and one part of saltpetre, should be finely pounded and mixed together and gradually heated in an iron pot till it is burnt. It should not be over heated, but as soon as it is thoroughly warmed, it should be kindled by means of a hot coal, or hot poker, it then burns slowly and does not arrive at a heat sufficient to melt it. The mass so prepared is once more finely pulverized and sifted and is then securely bottled and kept from moisture, and is ready for use. If tartar cannot be got, black flux may be made by dissolving sugar or starch in water, and mixing in this the potash or soda, in the proportion of one part of sugar to ten parts of soda or potash, and evaporating the mass to dryness. This mass should be pulverized and treated as above directed. It works well, but is not equal to the first, and requires large crucibles, as it boils up considerably.

Any of the copper ores, no matter of what description, if previously roasted, will make a good assay with black flux. The quantity used varies between three and four parts to one part of ore, and, if this mixture is not sufficiently fusible, the addition of half or one part of calcined borax will furnish a liquid slag which will permit the melted copper to pass to the bottom of the crucible. For this operation a clay crucible without either coal or plumbago, is preferable; as too much coal is detrimental to the fluidity of the slag. In this assay a quick heat is required, for, if

the crucible be too long exposed to the heat it is in danger of being cut through by the flux, and the charge lost.

The following is the plan of assay adopted at Swansea in Wales. One ounce of ore is pounded and sifted as fine as possible, and roasted in an iron pot for about twenty minutes, or until the blue flame disappears. When cold, it is again pounded and mixed with the following flux in the proportion of 14 or 15 dwts. to one ounce of the ore, viz., 28 dwts. of nitre (saltpetre) 8 dwts. of common window glass, 2 dwts. of calcined borax, 2 dwts of fluor spar, 32 dwts of argol (crude tartar). This mixture must be pounded and mixed with the ore in the proportion of three fourth parts to one of the ore, put into a crucible and melted. When the mass becomes fluid, and ceases to boil any longer, it may, to save the crucible, be poured into a hot iron mould or pot; as soon as it is cool enough to become solid, it may be immersed in water, the slag knocked off with a hammer, and the copper button weighed.

This assay does not always prove correct; the nature and composition of the ore occasion a necessary difference in its treatment. The quantity of the flux is rather small and is often increased to equal weight with the ore, but too much flux is as bad as too little, and both retain copper in the slag, either in the metallic state, or as an oxyd. A good button of metal has neither a very smooth nor rugged appearance; both extremes indicate a loss of metal. It should have a fine copper color, with a bluish cast, and not be too smooth. A whitish appearance of the button is decidedly bad, being the result of alloys which have combined with the copper, or the flux, when it is in too great quantity; it may be the result of too much argol, or of some coal which found its way into the crucible. If the copper has not all been separated from the ore, the slag ought to be pounded, washed, and proper care taken to save it, and, if grains of copper are found in it, they may be added to the button, but if in the form of an oxyd, which will be indicated by its brown color and porous texture, the slag may be finely pounded, mixed with a little quick lime, and melted again, and the copper, thus obtained added, to the first. This last operation is always one of very doubtful propriety. An assay which has been spoiled had better be repeated, as it is exceedingly difficult to extract a small quantity of metal from a red slag.

The copper obtained in these assays is seldom or never very malleable, being generally hard and brittle, but their appearance, color, lustre, and texture furnish indications of the correctness of the assay. If the button is very coarse, porous, and hard, and if it looks black and does not resemble copper, the yield is not correct, and the assay is lost. A new assay must be had in that case. If it is coarse, porous, and black, but slightly malleable, the assay may be good and the yield true; but it will be necessary to re-

melt this button. Another instance is, when the button exhibits a shade of brown upon its surface; but this is somewhat similar to the others just mentioned. When the button is re-melted, it yields about two-thirds its weight of fine copper, and must be broken or pounded and then melted or refined with an equal or double weight of flux; composed of crude or refined tartar, to which a little common salt has been added; to prevent the appearance of a red or burnt slag, a little charcoal, or coke, or some powdered stone coal, may be also used. The next species of button has a brownish red or copper color; this may be considered a good result and giving a good yield. If this button should be broken, and melted with twice or thrice its weight of the above mentioned flux, it will yield one half its weight of fine copper. The worst description of buttons are those having a white, gray, or yellowish color. These are useless, and the assay is a complete failure.

The first operation, in these assays, is the formation of crude copper, which must be refined by a second process of smelting. In the second operation, as much flux must be constantly present as will properly cover the metal, and prevent its oxydation, and consequent loss of copper; and, for that purpose, the best flux that can be used is the black flux, which has been already described, with the addition of a little common salt.

If, in the first assay, the ore does not contain sufficient iron, which will be denoted by the dryness and porous character of the slag, and the coarse and porous nature of the button, some iron must be added to it. Flux may assist in remedying the evil, but there is a danger of the retention of copper in the additional quantity of flux. Iron is, in such cases, the best flux, and must be used in the form of a fine powder, and as an oxyd, or iron ore.

To produce a good button at the first melting, the flux necessary for the operation must be composed of 3 oz. of argol, (crude tartar); 23 dwts. of nitre, (saltpetre); 10 dwts. of calcined borax; 10 dwts. of bottle, or window glass, and 6 dwts. of slacked lime. These ingredients should be well pounded, mixed together, and sifted, and is then ready for use. It must be kept in tightly-closed bottles, to protect it from the moisture. One ounce of the calcined ore, prepared as before described, should be mixed with one-and-a-half ounces, or a little less, of the last-mentioned flux. Two or three pennyweights of common salt, and an equal quantity of argol should be pounded and mixed together, put into a small crucible, and melted, at the same time that the ore and flux are being melted in another crucible. When the latter is melted, and ready to be withdrawn from the fire, it should be emptied into the other crucible, in which the flux is also in a hot fluid state, the motion produced by the discharge of the assay from one crucible into the other, will have the effect of gathering to-

gether all the stray grains of copper, which might otherwise have adhered to the sides of the crucible. When the latter crucible has been heated to the proper degree, the contents should be poured into an iron mould, previously heated and greased; or, it may be allowed to cool, and the crucible be broken, to obtain the button of copper, which is frequently found to be crude, and will, sometimes, require refining.

This last mode of assaying is never quite correct, and always falls short of what ought to be the true yield. It is a profitable assay for the purchaser of the ore, but an unprofitable one for the seller. Rich ores are more sensibly effected by the fluxes than the poorer kind, and lose a greater proportion of their metal. To prevent this, the amount of saltpetre and salt may be diminished, or entirely dispensed with, and the ores melted with argol alone, to which a small quantity of coal dust had been added. If the refining wastes more than one third of the crude copper, the first operation must have been imperfect, and the assay may be said to have been lost, or spoiled. A little experience will teach any one whether the ore melts too sluggishly, or too rapidly, on the application of the first heat. If it melts too rapidly, the flux is too sharp, and too fluid, and the assay is spoiled; but, if it is too tough in the crucible, the addition of a little borax, or fluor spar, will make it lively; the use of too great a quantity of these articles, has, however, a tendency to make the copper crude.

Refining.—The buttons thus obtained are not of a fine quality, and have once more to be broken up, and prepared for the process of refining. For this purpose a crucible is placed in the furnace, and, when brought to a white heat, the crude copper, which is being heated in a small crucible, must be thrown into the hot one, and melted rapidly; as soon as the copper has melted, a little of the following flux, which has been previously melted in another crucible, must be poured over the hot copper, and a few minutes after the contents of the crucible should be emptied into a greased mould. If the copper does not prove to be fine after the last melting, the operation will have to be repeated in the same crucible, until the copper has acquired the necessary fineness, which can be determined by flattening it with a hammer on an anvil, bending, and then breaking it. If the color and strength are satisfactory, the assay is, thus far, finished.

The slags, resulting from this refining operation, should be mixed with a small quantity of argol (tartar) and smelted in the same crucible in which the refining was performed, and, the grains of copper resulting therefrom, added to the button of refined copper, which will complete the assay. This grain often has the appearance of iron and should be refined before adding it to the former. This is the flux refered to above; for coarse or crude copper 1½ lbs. of nitre, 1 lb. of argol, ½ lb. common salt, well

pulverized and mixed together, and put into an iron pot, and stirred with a red hot iron poker, until it is properly and thoroughly burned. After which it is pulverized and bottled for use.

Assay of Lead ores. The assay of Lead ores is not very difficult, but it is an operation requiring more skill than might at first sight appear. It is so volatile that if the smelting operation be not conducted with great care considerable loss will occur rendering the result of an assay very doubtful. Lead ores may be divided into two classes. One class comprises those which contain no sulphur, the other class may be mixed with sulphur, or be pure sulphurets. The first can be assayed without the addition, the second requires the addition of metallic iron to produce satisfactory results. Lead does not require much heat, and a high heat should not be used. If losses are to be avoided by evaporation, a common stove, a fire grate, or any description of furnace, will suffice for this purpose, and black lead crucibles answer the purpose better than those composed of pure clay. If the latter are used they should be lined with a coating of charcoal powder or plumbago. An assay of lead can be performed to the greatest advantage in a cast iron crucible. Instances occur in which a great heat is required to smelt a lead ore; but these are extreme cases and should never be depended upon for correct results. Lead ores which do not contain any sulphur, such as red or white lead, should be smelted simply with black flux. If the ores are very pure, such as litharge, minium or red lead, white lead, and similar ores, there will be little or no flux needed. Common lead ores, such as are in a natural state, are never sufficiently pure to yield their lead when smelted, without the addition of flux. Such ores should be pounded, and roasted gently, or merely dried to expel the water which may be contained in them. The powdered ore may be mixed with pulverized black flux in the proportion of one ounce of the ore to two or more ounces of the flux. Two parts of flux to one of ore is generally sufficient, but there may arise instances in which that amount will not even make a fusible slag, and more flux will have to be added. There can be no objection to using as much flux as we please, but then it compels the use of larger crucibles, as this flux is very liable to boil and flow over. In cases when two parts of black flux is found to be insufficient, it will be advisable not to use any more flux, but to add carbonate of soda alone or in connection with a little glass of borax. With these additions to the flux, the process is always successful, provided we use a plumbago crucible, or one lined with charcoal or plumbago. The mode of performing the operation is very simple. When the flux and the ore are well mixed, it should be put in the crucible, previously well heated, and filled to not more than one third; the other two parts being needed for ebullition. The crucible should then be covered by a slab, or a good hard coal, and placed in a

cold furnace, the fire kindled, and the heat raised gradually, as a sudden and rapidly increasing heat is very apt to boil the mass violentiy, and, if the crucible be not very large, drive the contents into the fire.

A little common salt over the top of the ore will moderate the violence of the ebullition; but if this should not prove sufficient, and there is danger of the mass boiling over the top of the crucible, the cover should be removed, and air admitted, which will spedily diminish the agitation. As soon as the boiling ceases, a stronger heat may be generated, and the mass brought into a state of perfect fluidity; but a greater amount of heat should never be applied than will be actually necessary for the accomplishment of our design.

When the mass is properly melted, and appears in the crucible with a clear glassy surface, the assay is accomplished. The crucible should then be removed from the fire, cooled, quenched in water, and finally broken, to remove the button of lead, which is found in the bottom of it. There is generally no difficulty in separating the button from the slag, but it sometimes adheres to the crucible, when made of clay or iron. When this occurs, a great deal of chiselling is frequently necessary to separate the adherent particles. It is necessary in every case to pound the slag, wash it, and examine whether there are any grains of lead in it. It is usualiy soluble in water, therefore nothing is needed but to pound it coarsely and dissolve it in water. If there are any metallic grains contained in it, they will remain after the slag has been washed off. If the mass has boiled too strongly, and the fire has been too hot, the crucible will be very apt to retain some of the crude slag, and form globules of lead, which will adhere to the sides of the crucible. The loss of these globules diminishes the yield of the ore, and makes the assay incorrect. Such an assay cannot be remedied and is lost; the adherence of these globules to the crucible having been caused by the boiling, every effort should be made to avoid the inconvenience in a future operation.

The lead produced by such an assay is never pure, and always retains some traces of those metals which have been mixed with the ore, such as copper, silver, antimony, &c. It also invariably contains some potassium or sodium, which it receives from the fluxes. These admixtures are, however, in such limited quantities as to exercise but little influence upon the correctness of the assay. The loss by evaporation is of far more consequence, amounting generally to about ten or twenty per cent. If zinc and lead are found united in the same ore, and the proportion of the former be greater than that of the latter, the lead will frequently evaporate entirely. In this case the only chance of success exists in washing the ore, roasting it, and using an excess of flux in smelting it, taking

care to use only as much of the black flux as will barely precipitate the lead.

The Sulphuret of Lead, are those lead ores which contain sulphur and lead. They should not be roasted, but simply smelted with black flux and a little dry carbonate of soda, with the addition of some metallic iron. About 20 per cent. of iron, in the form of wire ends, cut into short pieces, tacks, or broken nails, is generally added, but no harm will result from the addition of a larger quantity, even were it increased to one half, provided the heat applied in the reduction be not so great as to reduce or melt some of the iron. Iron of a coarse form is the best for this purpose, as it can be so used liberally, and without any resulting evil effect, because it does not easily melt, and will take up the sulphur. The quantity of flux may be varied without occasioning much difference in the result, from one half to double the quantity of the ore. If the ore is a simple sulphuret, like galena, carbonate of soda and metallic iron will be sufficient for smelting it; but if it contains any oxyde, or other forms of lead, the black flux must be applied. The most perfect, and, at the same time, the surest way of assaying lead ores is in an iron pot or iron crucible. Any iron pot will answer this purpose, provided it be not too large. If one can be obtained having the form of a clay crucible, such as a carpenter's glue-pot, for instance, it will be well to procure it; still any iron pot, having a round bottom, is good enough for an assay of lead, and if black flux, soda, or nitre, cannot be obtained, a very efficient flux can be compounded of potash, to which soap has been added to an amount equal to the weight of the ore, and a small proportion of common salt. This flux should be mixed with the pulverized ore, and the mixture dried in an iron pot over a gentle fire; care being taken to stir it constantly to prevent its boiling over. When it is thoroughly dry, the stirring should cease, and the heat be gradually raised to the melting point. Sulphurets, in particular, smelt well in an iron pot. The best assay can be made in an iron crucible, as it furnishes the purest lead, and largest yield; for, when the loss in a clay crucible reaches 20 per cent., it will not average more than ten in an iron pot, but will require the same quantity of iron ore, as before designated.

Assay of Gold. Gold is generally, and we may say, usually found in its native condition, as a pure metal, but it is sometimes found in sulphurets, and in alloy with other metals. The sulphurets, or iron pyrites, are considered the most abundant source of gold in the United States, and very probably also in Canada. What may on examination prove to be the matrix of gold in the Canadian Gold fields, in the Dominion of Canada, yet remains to be determined. It however occurs in *situ in the quartz veins*, and very probably also, in the extensive deposits of iron pyrites that occurs so extensively, and are so generally distributed, throughout the

Laurentian formation, in which the precious metal, has now been proved to exist in large commercial quantities.

Should the gold in its native state be enclosed in other minerals, the ore may be pounded and washed, and the gold separated from it and weighed; but such an assay will be incorrect, as a large proportion of the smaller particles of the fine gold would be washed away, and more than half the actual contents of the ore lost. Such an ore may be *amalgamated* with mercury, which however, must be pure, but that process is, also, not quite safe, and remarkably slow and tedious. The best way is, in all cases to make an assay by the process of smelting. Gold ores are generally poor. It is therefore useless to smelt so small a quantity as one ounce, five ounces being little enough, in any case, for the production of a successful assay. The ore must be finely pounded, sifted, and at least an equal weight of litharge added to it. In most cases however twice or three times its weight of litharge may be required. When the ore is very siliceous (full of quartz) or sulphurous, (pyriteous) this will be the case. It will always be best to use a liberal amount of litharge, as it never does any harm, and may facilitate operations very much. The litharge of commerce is very poor, sometimes containing copper and iron, and frequently silver, which is worse than either, rendering an assay made with it quite incorrect. The surest plan to obtain a pure litharge is, to take acetate of lead and dry it by a strong heat, constantly stirring it, at the same time, to prevent it from smelting. The litharge obtained by this process may be considered free from silver. To the mixture of ore and litharge add a little black flux, just sufficient to afford carbon enough for the precipitation of a limited quantity of metallic lead. One part of black flux will produce one part of metallic lead; and as half an ounce of lead will be sufficient to absorb all the gold contained in the five ounces of ore, that we are supposed to use in the charge, not more than half an ounce of the black flux should be added. If however there are no pyrites in the ore, some carbonate of soda, or borax, may be added; but if sulphurets are present, (pyrites for instance) it will be advisable to use nitre. In most cases the assay, will be more perfect, if we abstain from the use of alkaline, such as potash and soda, fluxes entirely, and substitute litharge, and a small quantity of finely powdered charcoal. The assay must be performed in a crucible composed of pure clay, or, which would be preferable, in an iron pot. When smelting in the latter the contents should be emptied into a mould while hot, because it will be difficult to separate the mass from the pot, when it becomes cold. In smelting, the metal in the pot should be invariably covered with a layer of salt, as it facilitates the smelting, and the separation of the gold from the slag.

The lead button obtained by this process will contain all the

gold derivable from the ore under examination—whether it be in a sulphuret (pyrites), or in a silicate (quartz). One of the principal conditions of success is an accurate or approximate proportion of the ore and flux, as well as that of carbon: for the reason that black flux, such as we have described, is preferable to charcoal; but soap is better than either; soap, from its chemical composition, penetrates every ramification of the mass, and its carbon is brought into close contact with every particle of the ore. The application of alkaline fluxes is objectionable, so far as it causes an ebullition, or boiling of the mass; and, if sulphur be present, it will retain a portion of the gold.

From what has already been said, in previous pages, on *gold*, and the assay of other metalic minerals, the writer is of opinion that, were he to pursue the subject further, it would become wearisome to the exploring, hard-working, and industrious pioneer to read and study it, and to whom the commerce of the world is almost entirely indebted for the discovery of many, if not all, of those gold-producing fields, regions, and territories, that have hitherto supplied the precious metal, and created such a revolution, in migration, civilization, and commerce, even to the remotest and most uncivilized parts of the earth, that "other ages seldom knew."

Instead, however, as herein before stated, of pulverizing, washing, and amalgamating, or even smelting quartz-rock, which is known to contain gold, to determine whether that metal occurs in it, in paying quantities, and in what proportion, though invisible to the naked eye, or lens, it may be well to say that it can be readily determined by specific gravity.

The specific gravity of a body will be found by dividing the weight, in air, by its loss, when weighed in water. For example: A piece of quartz weighs, in the air, 293 grains. The same piece weighs, in water, 180 grains. The difference of weight is 113 grains. Divide 293 by 113, and you will have the specific gravity of the quartz; viz.: 2·58.

Suppose we find a piece of gold bearing quartz rock, in a gold-producing section of country, whose specific gravity, we find, by the above rule, to be 8·067, and in which gold is known to exist, and it is desirable to determine the relative proportion of gold it may contain.

The specific gravity of gold is 19·000; and, of pure quartz, 2·600.

1st. Deduct the specific gravity of the specimen from the specific gravity of gold, the difference is the ratio of the quartz by volume; viz.: 19·000 — 8·067 = 10·933.

2nd. Deduct the specific gravity of the quartz from the specific

gravity of the specimen, the difference is the ratio of gold by volume; viz.: 8·067 — 2·600 = 5·467.

3rd. Add these two ratios together, and proceed by the rule of proportion. The product is the proportion of gold by bulk: 10·933 + 5.467 = 16·400. 16·400 is to 5·467 as 100 is to 33·35.

4th. Multiply the per centage of gold by bulk, by its specific gravity—the product is the ratio of the gold in the mixture, by weight; viz.: 33·35 × 19·000 = 633·65.

5th. Multiply the per centage of quartz by bulk, by its specific gravity. The product is the ratio of quartz in the mixture, by weight; viz.: 66·65 × 2·600 = 173·29.

6th. To find the per centage of gold, add the two ratios, 633·65 + 173·29 = 806·94. As 806·94 is to 633·65 so is 100 to 78·53, the product of gold, by weight, in the specimen.

Assay of Silver Ores.—Silver is not often found in a chemically pure state, and should only be smelted with as much metalic lead as will absorb the impurities which may be enclosed in the silver mineral. Native silver is usually found alloyed with gold, which may be separated by the dry analysis in the crucible; but the humid method, by acids, is the most simple and certain in its results.

Silver ores are found in a great variety of forms, and in combination with almost every other kind of material, to form an ore. If the amount of silver contained in a mineral is too small to repay the cost of extraction, it may still be regarded as a silver ore, but may be used for some other purpose. Silver ores are assayed nearly in the same manner as gold ores; differing, however, in the greater degree of heat used; silver requiring a higher temperature to smelt it than gold. Most of the silver ores contain sufficient lead to make the addition of that metal, in the smelting process, superfluous. In that case, the ore should be treated exactly as a lead ore, with the exception that little or no iron should be used in the assay, but principally black flux and borax. It is of little consequence if lead remains in the cinder, for the greater portion, if not all of the silver, will follow the bulk of the lead. All the silver will be obtained by the application of a strong heat, no matter how much lead may accompany it. The object aimed at, in this assay, is to produce but little lead, and obtain all the silver. This can be accomplished if the ore has been properly roasted (often a tedious affair) and the assay be made with saltpetre and argol, to which borax may be added. If the assay be performed in this manner, it will be perfectly safe, provided all the conditions of the process be complied with; but, as it may be doubtful whether reliance can be placed upon an adherence to those requisites, it will be advisable to follow another plan which, though more tedious, is certain of success. If the ore is rich in silver, a portion of the litharge,

made of acetate of lead (sugar of lead) should be added; the quantity of litharge may be optional, but should always be in an inverse proportion to the amount of lead contained in the ore. It is not necessary to use so large a quantity of silver ore as would be required of gold ore, in these operations. For practical results, one ounce may, in all cases, be considered sufficient. A very perfect solution of iron will be needed in the flux, and if the ore contains much silica, lime, or other foreign matter, which cannot be removed by washing, a large quantity of litharge will have to be employed. When the ore has been washed and finely pounded, it should be mixed, as the case may require, with more or less litharge. (In some cases it will not require any). An addition of half an ounce of black flux should be made, which will produce half an ounce of lead. The powder of charcoal made of hardwood, is better than black flux. One part will make thirty parts of lead, reduced from the oxyd. Eight grains of charcoal will make 240 grains, or half an ounce of lead. In every instance, a half ounce, or one ounce, of dried or burned borax should be added to the mass, which should be thrown loosely into a dry crucible, and not more than one third fill it; over which should be spread a layer of common salt, the crucible covered, and then exposed to heat, which should be strong and rapid, and in consequence of this indispensable requisite, the application of alkaline fluxes, such as saltpetre, soda, &c., would be injudicious; litharge and glass of burnt borax should finish such an assay. Boiling, in this case, should be avoided more than in any other case; and, if it cannot be entirely prevented, it should be diminished as much as possible, which can be in a great measure prevented by the application of salt over the charge, or by opening the cover of the crucible.

If the silver ore is a perfect sulphuret, or silver in combination with sulphur, the assay may be made comparatively easy, by pulverizing and mixing the crude ore with an equal weight of litharge, and nearly half its weight of nitre. If there is a large proportion of iron, or copper pyrites, in the ore, the amount of litharge and saltpetre should be proportionably increased. Iron pyrites require four times the above weight of nitre; copper pyrites three times that amount. This mixture will produce all the silver in a very small quantity of lead. If the alloy contains too much saltpetre, it will not produce any lead at all; but this evil may be remedied by the addition of some small chips of metallic lead to the fluid mass. Any ore will readily yield its silver on the liberal addition of litharge; while the presence of alkaline fluxes is not so favourable to the precipitation of silver, but has a tendency to produce more lead.

Refining lead, to obtain the gold and silver is not a very easy process for the inexperienced, and we would advise recourse to be

had to an experienced professor, or metalurgist; but as this is extremely difficult in some, and impossible in other instances, we will endeavour, in as plain and brief a manner as possible, to lay down such rules as will guide the experimenter, to a somewhat satisfactory result.

The silver and gold in the foregoing assays, having been alloyed with a large portion of lead, the following assay by the cupel, is designed to destroy the lead and other metals, and produce the gold and silver in their pure state. The principle upon which this process is founded is the feeble affinity which gold and silver have, comparatively with other metals, for oxygen. The other metallic substances contained in the assay will rapidly absorb oxygen, melt and sink, like a fluid glass, into the pores of the cupel, which are not, however, large enough to absorb the gold and silver metals. We have already described the mode of constructing a *cupel* for small assays, similar to those we have been describing. The next apparatus to prepare is a *muffle*. This is a box made of fire-clay, shaped like a traveller's trunk, in which one end is wanting, and about three-eighths of an inch thick, one foot long, six inches broad, and four inches high, and provided at the top with numerous small oblong holes. This *muffle* should be made of good fire-clay, capable of resisting a strong fire, and enclosed in a furnace by a wall, in such a manner that the fuel may completely surround it. In this muffle the cupel or cupels should be placed for refining. They may be purchased ready made in the large cities, but, at a distance from such places, this is impossible, and we shall, therefore, point out their mode of construction. Instances may occur rendering an assay imperatively necessary, and, if no muffle can be procured, or prepared on the spot, a good sized crucible may be selected, a hole driven through the bottom of it, and the *cupel* containing the lead placed therein. The crucible should then be placed in a furnace, in such a position as will admit a draught of hot air through the bottom of it. After every preparation has been made, *the process of cupelling* becomes very simple. The muffle should be heated, and the cupel, containing the lead, to be operated on, placed in the mouth of it, so that it may receive the heat very slowly. When all the moisture has been expelled from the cupel, it may be pushed further into the muffle, and a stronger heat applied. The bone ashes will soon assume a very white appearance, and the metal will look red, and, if the cupel is surrounded by an iron band or hoop, the metal will appear dark red. The heat should then be rapidly increased, but not made too intense; for, if the lead becomes too lively, evaporation will succeed, and the lead vapors will carry with them the silver or gold. The best heat is that which is just sufficient to prevent the lead from chilling, and heat the oxyd of lead to the degree necessary to allow it to sink in the cupel and

not form a cold black ring around the hot lead; but when this happens, the heat should be increased, and the cupel will absorb all the oxyd made by the test. The lead should not only be kept liquid, but also in lively motion, until nearly the whole of it is absorbed by the cupel; the heat should then be rapidly increased to the highest degree (a bright white) to melt the scattered silver or gold into a round globule. When all the lead has disappeared, and not previously, a bright, shining metalic globule will appear. The cupel should then be removed from the fire, and, when cool, the globule separated from it and cleansed from the adherent dirt, and weighed. An assay of this description is never quite correct, the yield being always too small. In large operations the yield will be greater from the same ore, or lead. If the difference of yield in large and small operations were always the same, there would be no evil resulting from it; but this is not the case, the multiplied and complicated operations necessary in assaying, cannot be conducted with so much precision as to produce uniform results. In all assays made immediately from the ore, silver will be found more or less alloyed with gold, and gold with silver. As the separation of these two metals by the dry or smelting analysis is uncertain and tedious, we will describe a process by which an approximate result may be easier obtained. The proper method of separating gold and silver is by the humid or acid process; that is, to dissolve the alloy, or rather the silver it contains, in nitric acid, which alone will not effect the gold, and precipitate the silver by means of a solution of common salt. To separate gold from silver or other metals by dry analysis, it should be mixed and melted with three times its weight of the sulphuret of antimony, which may be obtained in the drug stores. This alloy should be run into a mould, cooled, the slag knocked off, and the brittle regulus or button melted in a fresh crucible and treated as before. In the second smelting some saltpetre and a little common salt should be added; these will destroy and oxydize all metals except gold. If the button thus obtained should be found brittle and hard, the same smelting process, with the addition of saltpetre, and salt should be once more repeated. If, after this, the gold remains impure, more antimony should be melted with the gold, and the refining process repeated, until the experiment proves successful. By this method all the gold will be obtained pure; and the difference in weight between the gold and the metal received from the cupel will be silver, if cupelled metal has been used. All the metal to be assayed by this operation should be the result of cupelling; and for this reason, all gold and silver ore from which it is desirable to obtain pure gold, should be melted with gold and cupelled.

If the gold be in fine grains, such as wash gold, usually is, or amalgam, it should be purified by mixing it with a little corrosive sublimate or calomel, heating it at first gently, and then raising

the heat until it melts the gold. This operation should be performed in a new crucible; the silver, and other metals, are then lost by evaporation. If, in these operations, any silver should remain in the slag, it may be recovered by smelting it with argol, to which a little charcoal dust has been added. The recovery of the silver will, however, be more certain, if the slag should be treated as a poor silver ore, pounded, smelted with litharge, and then cupelled as previously described. If gold or silver is alloyed with platinum, irridium, rhodium, or copper, the separation of these metals will be very difficult; the alloy must be subjected to the humid analysis, as, in all such cases it would be utterly useless to endeavour to make a good assay by the dry process. Such alloys may be melted with lead; but in cupelling, they cannot be separated,—not even the copper will, in this case, leave the other metals.

Mercury occurs native, alloyed with silver, and in combination with chlorine or iodine. Its ores are completely volatile, excepting the one containing silver. Traces of mercury have been found by the members of the geological survey in the gold fields of the Province of Quebec, in the Dominion of Canada, and attention is called to that fact, and also to the report of an extensive deposit said to have been discovered in the Laurentide rocks some distance from the north side of the Saint Laurence River, not far from Quebec, but the exact where-abouts of which is kept a secret by the discoverer. It is not however improbable that further discoveries and developements may be made in our primitive rocks, as the progress of exploration is extended.

Native mercury is however a rare mineral, yet it is found at different mines of this metal, in Siberia, Spain, Austria, Hungary, Peru, and California. It is usually in disseminated globules, but is sometimes accumulated in cavities, so as to be dipped up in palls. It is used extensively for the extraction of gold and silver ores, and is exported in large quantities to gold and silver producing countries. It is also employed for silvering mirrors, thermometers, and barometers, and for various other purposes connected with medicine and the arts.

Cinnabar.—Sulphuret of mercury. This is the ore from which the principal part of the mercury of commerce is obtained. It occurs mostly in connection with *talcose and argillacious shale*, or other stratified deposits, both in the most ancient, and in those of more recent date. This mineral is too volatile to be expected in any abundance in proper igneous or crystalline rocks, yet it has been found sparingly in granite. This ore occurs as earthy coatings, tabular crystals, six sided prisms, and massive. Lustre unmetallic, adamantine in crystals, often dull. Color bright red, to brownish-red, and brownish-black, streak red. Subtransparent to nearly opaque. Hardness 2 to 2.5. Gravity 6.7 to 8.2. When

pure it contains about 86 per cent. of metalic mercury, and 14 per cent of sulphur, but it often contains impurities. The pure variety volatilizes and disappears entirely before the blow pipe, and this character will readily distinguish it from red oxyd of iron, red lead, and chromate of lead; and from *Realgar* or *red sulphuret of arsenic*, by giving off when heated on charcoal, no garlic odor. In an assay the cinnabar should be pulverized and mixed with half its weight of iron filings or borings, and some slacked lime or soda, the mixture put into an iron retort to about one-third its capacity, and the retort *gradually* exposed to a strong red heat, otherwise it may break the retort. The neck of the retort should be prolonged by an iron pipe about two feet long, which should be surrounded by another pipe made of tin, sufficiently large to leave a space between the two. Through this latter pipe a current of cold water should be made to pass from the lower to the upper end, which will keep the pipe cool, and condense the mercurial vapor as it passes out through the iron pipe. It will pass from it in a metallic state in drops, which may be collected in an iron or porcelain basin, filled with water. The fire should completely envelop the retort to prevent the adhesion of quicksilver at its top. A strong heat, and a sufficient amount of iron will drive the last traces of mercury from the ore. If an iron retort cannot be obtained, a stone-ware bottle, an earthen jug, or still better, a common cast iron coffee kettle, which can be procured in almost every place, may be employed. The lid of the kettle must be tightly cemented with strong clay, moistened with salt water or a solution of glauber salt, and be held down with an iron bar passed through both of the ears to which the handle is attached. A substitute for the pipe may be made of sheet-iron, the joint well closed and the pipe well bound with iron wire. The joint should be turned upward and made tight by the application of fire clay, and the pipe led over a basin containing water, so that the mouth will be about two inches above the water. A moist rag, kept constantly wet with cold water, must be kept on the pipe to condense the vapor of mercury as they descend the pipe, and make it drop into the basin of cold water. The mercury collected in the basin, should be put in a bottle and weighed, which will indicate the yield of the ore.

CONCLUDING REMARKS.

When a section of country is suspected to contain gold the points to be most carefully examined are the quartz veins cutting through talcose, chloritic and other shales, and the sands of the rivers flowing over or through them, as well as the iron pyrites and particles of disintegrated rock, which often accumulates in the eddies of ravines formed on the sides of hills by the action of water during great floods. The sections of rock thus laid bare should also be examined and tested with a view to the discovery of veins of auriferous quartz, from which specimens should be broken and carefully assayed.

In examining the sands brought down by rivers, such portions should be selected for experiment as have, from local causes, been subjected to the action of rapid currents and eddies; since, from the great specific gravity of the metal sought, it invariably accumulates in those situations.

It is usually found that if a river or creek produces fine scaly gold in those parts of its course which lie through a flat open country, it will, if followed into the mountainous districts, in the direction of its source, become more productive and yield gold in the form of "nuggets," and less finely grains; but as before stated, these will always be found near the place from where they were separated from the containing rock, as gold will not, from its extreme softness, bear much attrition or rubbing, and will soon wear away to an impalpable dust and become lost. The most productive localities hitherto found have been the bends or curves of rivers, and in these places the conformation of the banks on the convex and concave sides of the stream are found to be materially different. On the convex side, the banks consist of gradual slopes, or accumulated drift flats, while the opposite side is more rugged and bluff. This is often occasioned by the dip of the rock in disturbed strata, and sometimes by the reverberation or reflection of the stream from an opposite perpendicular cliff. In all such slopes and flats, gold is found to be much more plentiful than along the margin or in the bottom of the same river, where the water flows through a straight and uninterrupted channel. The quartz rock in auriferous localities is frequently stained of a rusty brown color from the presence of peroxyd of iron, and in many instances presents a honey-comb red appearance.

When an auriferous deposit is situated at a distance from any creek, pond, or stream, its working is called dry digging, and the earth and sand have to be carried or carted, for the purpose of washing, to the nearest available water. River diggings are, however, generally speaking, the most productive, and in these the larger fragments, or nuggets, are most frequently found. In such localities, however, a very careful examination is required, as the gold is seldom found at the surface, but at a greater or less dis-

tance below the present bed of the river, and the nuggets and larger grains are most frequently from lodes and crevices existing in the rocks on which the sand and gravel repose. When the surface consists of loose gravel, the gold will, in most instances, have subsided beneath the coarse deposit, and will be found mixed with a sub-strata of tough clay, where that exists, and which is not readily disturbed or broken up by the current of the stream. On the surface of this second bed the gold will be found to be distributed in a thin stratum, which should be carefully collected and washed. Where this stratum of clay does not occur, and the superincumbent drift is of a loose porous character, the bed rock should be reached, its surface carefully scraped, and the accumulations thereon washed and examined. With the view of reaching the stratum of clay, or the bed rock in the bottom or sides of a stream trenches are dug, and by means of what are called "back troughs," the course of the stream is entirely diverted. When the bed of the creek has been thus exposed, and all the larger pebbles and gravel removed, the exposed stratum of tenacious clay must be collected and carefully washed; or, when that does not occur, the bed rock should be carefully examined.

Parties prospecting should carefully examine the surface of the country in order to discover the beds of old streams, now become dry, through the rivers, which formerly passed through them, having been diverted into other channels. By carefully examining these old water courses, it will be easy to ascertain, and determine the points at which eddies formerly existed; and in such places a search is often well repaid. When such a place has been found, the earth, and sand, should be removed, until the original bed of the stream has been reached, and, when this can be effected the firm blue clay should be collected and washed as in the case of that which occurs in existing rivers, and, where the clay does not exist, the bed rock should be reached, and its surface and crevices carefully scraped and examined. When such places prove productive, pits and audits will have to be sunk, and run, (sometimes to a considerable depth, and distance), and from some of which, in other countries, hundreds of pounds worth of gold have sometimes been collected in a single day, by persons with only the most rudimentary knowledge of mining.

Explorers should in all cases, as well as the above, look out for *Talcose* shale, *chloritic* shale, *schistose* shale, and *micaceous* shale, and where the quartz veins *run through* them, *see well to it;* at the same time the *ochreous matter* in the cavernous quartz; the *black oxyd of iron*, and *titanic iron*, (or black sand); and iron pyrites, should also receive attention.

The characteristics of gold from various localities, is very variable in composition and purity, and ranges from 60 per cent of gold in the lowest, and 88½ per cent of silver as the highest, in

some parts of Russia, and 95.68 of gold, and 3.92 of silver, in Bathurst, in Australia, to 98.06 of gold, 1.39 of silver, and 0·15 of iron, in Africa, as the highest. Some of the Australia gold contains from 0.16 to 0.57 per cent of iron; and, in all countries, it is rarely found without traces of copper, iron, palladium, or rhodium, and often several of these in combination.

Gold is so extremely malleable and tenacious that one grain of it may be beaten out into a leaf of 56 square inches, and only one 200,000th of an inch thick. It will then, to a certain degree, be transparent, and, on being held against the light, appears of a beautiful green color. This metal melts at a temperature of 2016 degrees, Farenheit, and when heated to a higher degree, gives off metallic fumes. A globule of gold exposed between two charcoal points, to the action of a powerful galvanic battery, gives off abundant metallic vapours, by the escape of which, its weigh is rapidly diminished. When precipitated from its solutions, gold assumes a dark brown color, but on being rubbed with a piece of smooth steel, or other hard body, it readily assumes its ordinary yellow color and metallic aspect. Pure gold may be exposed for an indefinite length of time to the action of air and moisture, without becoming in the least degree tarnished; nor is it oxydized by being kept in a melted state in an open crucible. Neither sulphuric, nitric, or hydrochloric acids will, singly, attack gold, even when in fine powder, or dust; but, in a mixture of hydrochloric and nitric acids, in the proportion of one part of nitric to two parts of hydrochloric acid, it is readily attacked and disolved, in the form of a chloride. This mixture is also a solvent for platinum, phosphate of lime, and many other substances, not acted on by one single acid. Gold may also be dissolved by hydrochloric acid, to which has been added some substance capable of liberating chlorine; among which may be mentioned chromic acid, and peroxyd of manganese.

Gold is not directly attacked by sulphur, at any temperature; but, when fused with alkaline sulphides, it is readily acted on with the formation of a double sulphide of gold and the alkaline metal employed.

We have, in another part of this work, already pointed out certain necessary processes for the determination and collection of the precious metal from alluvial soil, &c.; &c., but we deem it necessary to repeat that, the examination of an auriferous rock for gold, is an extremely simple operation.

First, pound it very fine, and reduce it to an impalpable powder, then wash it in a shallow iron wash-pan; and, as the gold sinks, the lighter portions of the substances pounded must be allowed to float off into some other receptacle. The largest part of the gold will thus be left in the angles of the pan; and, by repeating the process, a further portion will be obtained, till suffi-

cient is collected, when the gold may be amalgamated with clean mercury, and the amalgam obtained, after being strained through buck-skin, heated in an iron retort, or clean iron ladle, by which the mercury will be expelled, and the gold remain in the vessel. By successive trials in this way, or those already pointed out, the proportions of gold contained in a specimen of rock, pyrites, or alluvial gravel, may be ascertained with considerable accuracy.

This principle, of the affinity of mercury for gold and silver, is taken advantage of, and largely employed in the treatment of auriferous substances, and silver-bearing ores.

If the ore to be operated upon should be iron pyrites, pulverize it to a fine dust, as before, and boil the specimen powder in nitric acid. It will become dissolved with evolution of copious red fumes, whilst the gold, which the pyrites may hold, will in no way be effected, and will remain at the bottom of the flask, in the form of a fine sedimentary deposit.

To determine whether the ore contains copper, pulverize it in an iron mortar, or, if that cannot be got, pound it with a hammer, on a clean flag stone, and dissolve the powder thus obtained in nitric acid, and evaporate the solution, nearly to dryness, in a saucer, or some other shallow vessel; add water and afterwards ammonia (spirits of hartshorn) in excess. If the liquor assumes a blue color, it is proof of the presence of copper in the mineral examined. If copper be present in appreciable quantity, a knife or other clean bright piece of steel, will immediately become coated with it, if immersed in the dilute *nitric acid* solution.

APPARATUS AND RE-AGENT REQUIRED BY THE GOLD ASSAYER.

Apothecaries scales, with weights from 1 to 1000 grains. Assay balance, of good make, with weights from 1 grain to $\frac{1}{1000}$ of a grain. Forceps. Fireclay crucibles, in sizes. Two hammers, weighing respectively one and two pounds. Tongs, both curved and straight, for holding crucibles, cupels, &c. Cast iron ingot mould. Assay furnace, with muffles. Scorifiers. Steel stirring and cleaning rod. Anvil. Copper scoop. Cutting pliers. Small shears. Scissors. Cold chissels for cutting metal. Set of files. Small rolling mill. Iron mortar and pestle. Set of Sieves (fine wire gauze.) Cupel mould. Bone-ash, for making cupels. Scratch brush. A few glass flasks. Glass funnels. Stoppered bottles. A small pallet knife. Small porcelain crucibles. Spirit lamp. Poor lead for assaying, both granulated and in sheet. Litharge. Anhydrous carbonate of soda. Dry borax. Crude tartar. Nitre. Pure nitric acid, and hydrocloric acid.

TABLE

Shewing the quantity of Gold in a ton of Ore, when 400 grains of the rock, or veinstone, will produce the following results:

If 400 grs. of ore give fine gold.	One ton of ore will yield.			If 400 grs. of ore give fine gold.	One ton of ore will yield.		
GRAINS.	OZ.	DWTS.	GRS.	GRAINS.	OZ.	DWTS.	GRS.
.001	0.	1.	15	.200	16.	6.	16
.002	0.	3.	6	.300	24.	10.	0
.003	0.	4.	21	.400	32.	13.	8
.004	0.	6.	12	.500	40.	16.	16
.005	0.	8.	4	.600	49.	0.	0
.006	0.	9.	19	.700	57.	3.	8
.007	0.	11.	10	.800	65.	6.	16
.008	0.	13.	1	.900	73.	10.	0
.009	0.	14.	16	1.000	81.	13.	8
.010	0.	16.	8	2.000	163.	6.	16
.020	1.	12.	16	3.000	245.	0.	0
.030	2.	9.	0	4.000	326.	13.	8
.040	3.	5.	8	5.000	408.	6.	16
.050	4.	1.	16	6.000	490.	0.	0
.060	4.	18.	0	7.000	570.	13.	8
.070	5.	14.	8	8.000	653.	6.	16
.080	6.	10.	16	9.000	735.	0.	0
.090	7.	7.	0	10.000	816.	13.	8
.100	8.	3.	8	20.000	1633.	6.	16

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